Why Your February 15 Issue *Is the Industry's Standard*

WHEN EVALUATING forecast-review statistics published by various sources, oil men must carefully weigh three important factors: Experience —Accuracy—Completeness.

Here is the WORLD OIL record in these departments:

- **Experience.** The 1959 annual Forecast-Review Issue will be the 41st to be issued by Gulf Publishing Company—one of the industry's oldest, and most reliable, statistical reports.

- **Accuracy.** WORLD OIL's statistical forecasts are known throughout the industry for accurateness. To give but one example, the editorial staff's mid-year forecast for new U. S. well completions was 47,952 wells. The actual total for 1958 was 48,331 wells—*379 wells, or less than 1 percent greater than the* WORLD OIL *forecast made six months earlier!*

- **Completeness.** Few forecast-reviews, if any, are available that have the scope of WORLD OIL statistics. Virtually every phase of drilling, production, exploration, international operations and future trends is covered in detail, based on well-documented facts.

With this solid background behind it, there is every assurance that you will receive one of the top publication values of 1959 when the February 15 Forecast-Review Issue of WORLD OIL reaches your desk. Also, there is every assurance that your upcoming *extra* issue is the *industry's standard.*

In March, watch for

. . . When do I cut my drilling line?

An illustrated discussion of the importance of a well-planned drilling line cut-off program and how to recognize and/or minimize line failures.

. . . Unique program combats external tubing corrosion

Full particulars on an unusual automatic inhibitor injection system which has been developed and used successfully in directionally drilled wells at Redondo Beach, California.

AND

The Production File Series on Reservoir Engineering by Professor Frank W. Cole will be resumed. This easy-to-read installment will deal with reservoir studies.

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WORLD OIL

SPECIALIZED FOR EXPLORATION, DRILLING AND PRODUCING OPERATIONS AND MANAGEMENT

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VOLUME 148, NO. 2 FEBRUARY 1, 1959

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For a 'Quick Look' at this issue, turn the page . . .

a *Quick Look* at WORLD OIL this issue

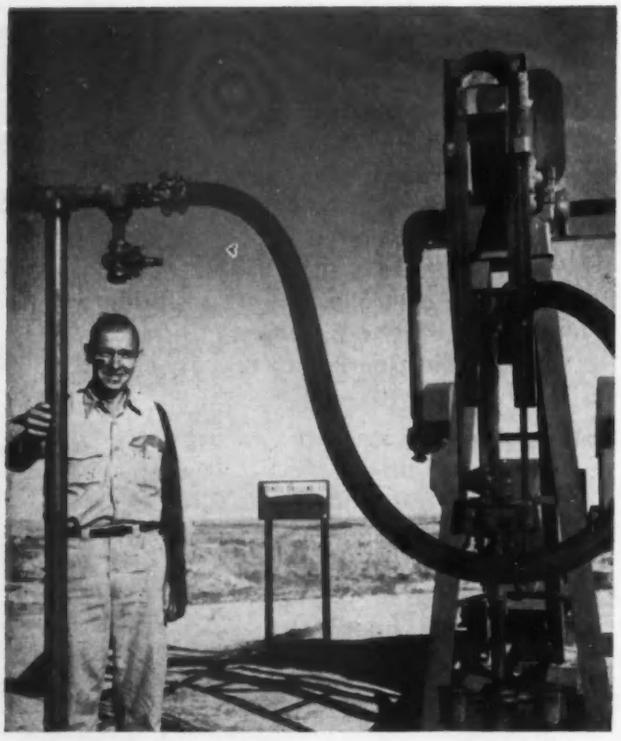
BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first

☐ **Six or 8 lines . . . which hoisting system is better? . . .** Many factors should be considered in determining the number of lines to be used on a rotary drilling rig, including:

- Load capacity of the derrick
- Design stress of the wire line
- Bending stress in the wire line
- Shock and impact loads
- Required rope speed

For a discussion of these factors and their effects when using eight lines instead of six to reeve the derrick, turn to.....**Page 61**

☐ **Present methods of determining the liquid/solid ratio** are believed to be inadequate to estimate clay content. Here is an article that discusses a new concept or method calculating the total mud solids in drilling muds.....**Page 66**



Surface installation for well pumping through 1-inch pipe.

Pattern-shooting seismograph techniques have injected

☐ **Success in the use of 2½-inch tubular goods** as casing is dependent upon correct application of field techniques and use of proper equipment. The slim hole completion method offers substantial savings to operators under proper conditions.....**Page 70**

☐ **Gas-bearing zones are detected successfully** in cased hole or open hole through the use of radioactivity logs. Numerous examples of the successful use of single and multispaced neutron logs are presented, as well as examples of the detection of gas, distillate, oil-bearing and water-bearing sands by proper interpretation of radioactivity logs...**Page 79**

☐ **A material balance equation has been developed** for gas reservoirs with water drive by combining a simple material balance equation with the Schilthuis water influx equation.....**Page 63**

☐ **Changing flow rates will develop a surging effect** in the pump discharge line. This installment of "Know Your Mud Pump" discusses how this condition can be minimized through the use of properly located dampeners.....**Page 75**

☐ **Oil possibilities of the Bahamas** are similar to those of southern Florida and northern Cuba. Structures probably will vary from strong, simple folds

north of Cuba to gentle folds approaching Florida. Salt domes and stratigraphic traps are possibilities.... Page 85

☐ **Laboratory research has proven successful** in combating water encroachment in air and gas drilling. Practical drilling conditions were simulated in the laboratory so as to relate actual field operations. These laboratory techniques and results are discussed in the first of a two-part article.....Page 90

☐ **Needed: Wider well spacing . . .** High costs and economic wastes are crippling the oil industry. Contributing to these ills is an unrealistic well spacing program in many of the oil-producing states. Here is a timely, authoritative discussion of this controversial problem, plus a suggested solution that would include a flexible step-wise program that can later be adjusted to engineering and economic facts. Page 98

new hope into the persistent search for oil in Israel.

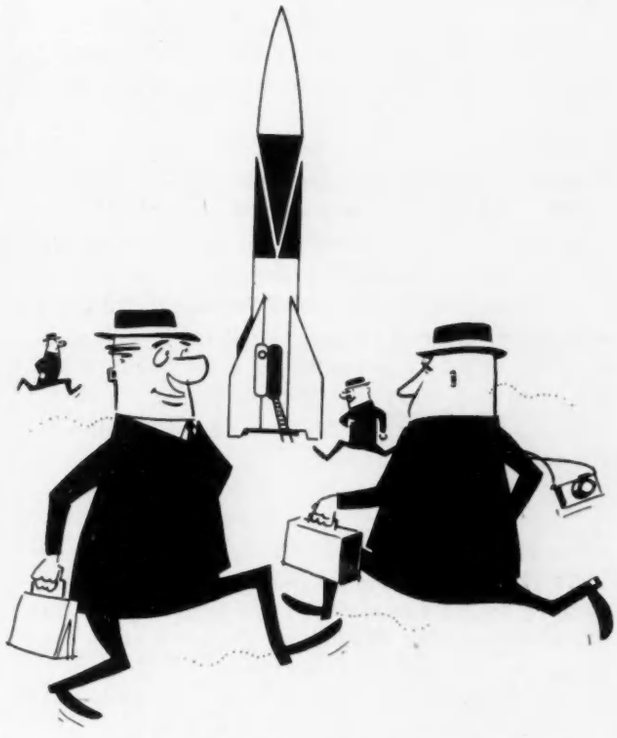
☐ **The exploration outlook in Israel** has brightened considerably. Pattern-shooting seismograph techniques have enabled Pan-Israel Oil Company, Inc., and Israel-Mediterranean Petroleum, Inc., to acquire good records in areas where no satisfactory records were obtained before. Earlier records, based on conventional single shot techniques, were poor and/or unusable. They were unsatisfactory because heavy absorption of seismic energy in unconsolidated sediments and cavernous, flinty limestones. For a complete report on adaption of pattern shooting to the search for oil in Israel, turn to.....Page 106

Editors on the go

EVER WONDER, when you see WORLD OIL editorial staff men at the many oil industry meetings held each year exactly why they attend? Of course, they attend to study the papers and to hear addresses. But there are many other major reasons, too.

Our editors attend meetings to meet YOU, to find out which of the papers presented at these meetings interested YOU the most, to learn what additional subjects interest YOU, to find out whether YOU are preparing a paper which will interest others of our subscribers, to have YOU outline what industry problems are facing YOU.

The important thing—to YOU—is that our editors



WORLD OIL editors will get around in '59.

attend these meetings and talk with hundreds of oil men representing every branch of the producing, drilling, exploration, and management divisions, including consultants as well as representatives of independent and major oil companies.

And because of an extensive travel program which, again in 1959, will send WORLD OIL editors into virtually every section of the United States, they may have an opportunity to find out how others are solving problems which YOU may have. And they'll be glad to, if YOU give them the chance when next you see them.

Centennial comment

To the Editor:

Your January, 1959, issue commemorating Oil's 100th anniversary must have involved a lot of very hard work on the part of your editorial staff. They are to be congratulated for a good job.

Our editor has called attention to the table on Page 156, titled "Free World Geophysical Activity by the Petroleum Industry during 1957." He points out that the figures in the table were taken from the report of the SEG Committee on Geophysical Activity, but that mention of the source was omitted. You may wish to publish an addendum.

Colin Campbell
Business Manager, SEG
Tulsa

Our apologies for this ommission, which is hereby corrected—Ed.

To the Editor:

Your January number is just wonderful and very comprehensive.

Frederick G. Hehr
Hehr Subsoil Analysis
Los Angeles

To the Editor:

I was very favorably impressed with "A Century of Oil" which appears in your January, 1959, issue.

This study is so well done, it occurs to me that you might have plans for printing the article (or series of articles) in a separate booklet for popular distribution.

Would you be good enough to tell me if such separate prints might be available in some quantity and if so, when and what the price might be.

You are to be congratulated on this carefully detailed and informative report.

Weldon J. Allen
Houston

Extra issues of the January issue are available for $1 each while the supply lasts. They may be obtained by writing to the Circulation Department, P. O. Box 2608, Houston. The Production Department is considering the possibility of reprinting "A Century of Oil," and if reprints are made available, an announcement will be made in WORLD OIL—Ed.

Editorial index available

ORDERS ARE now being taken for the Annual WORLD OIL Editorial Index. This annual service to WORLD OIL readers covers all 14 issues published during 1958 and is bound in convenient pamphlet form. It will be sent free to all WORLD OIL readers requesting a copy.

To get a copy, address your order to: Librarian, Gulf Publishing Company, Post Office Box 2608, Houston 1, Texas. Or if you prefer, use the convenient Reader Service Blue Postcard just inside the back cover of this and every issue of WORLD OIL. Merely check the square indicated, fill in your name and address and drop the postage-paid card in the mail.

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SUBSCRIPTIONS

F. G. Spindle, Subscription Manager, P. O. Box 2608, Houston, Texas, U. S. A.

Single copies 50 cents (except special issues). Double prices for single copies more than one year old. Subscription price: domestic and foreign, $2 a year.

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Postmaster: Send notification (Form 3579) regarding undeliverable magazines to World Oil, Box 2608, Houston 1, Texas.

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WORLD OIL and THE COMPOSITE CATALOG for the drilling-producing industry.
PETROLEUM REFINER and THE REFINERY CATALOG for the oil, gas and petrochemical processing industry.
PIPE LINE INDUSTRY and THE PIPE LINE COMPOSITE CATALOG for the oil and gas pipe line industry.

Indexed by Industrial Arts Index and Engineering Index

Looking Ahead

Prediction: U.S. Wells, Footage to Increase in '59 . . . World Oil forecasts 50,275 new well completions this year, up 1,944 wells or 4 percent over '58 total of 48,331 wells (See Page 28). Footage drilled will increase 3.7 percent—from 195.8 million feet in '58 to 203 million feet in '59.

Total new completions in '58 were down 5,452 wells (10.1 percent from previous 12 months. Footage drilled dropped 25.1 million cubic feet (11.4 percent) from 220.9 million feet drilled in '57.

New Producing Zone for Los Angeles Basin? . . . Flurry of new drilling activity is expected to follow recent discovery of flowing production from the schist, a basement formation in Los Angeles Basin's Wilmington field. Surrounded by wells producing from shallower zones, the new well was completed flowing at beaned-back rate of 375 barrels per day of 28.7 gravity clean oil from 6,315-6,698 feet.

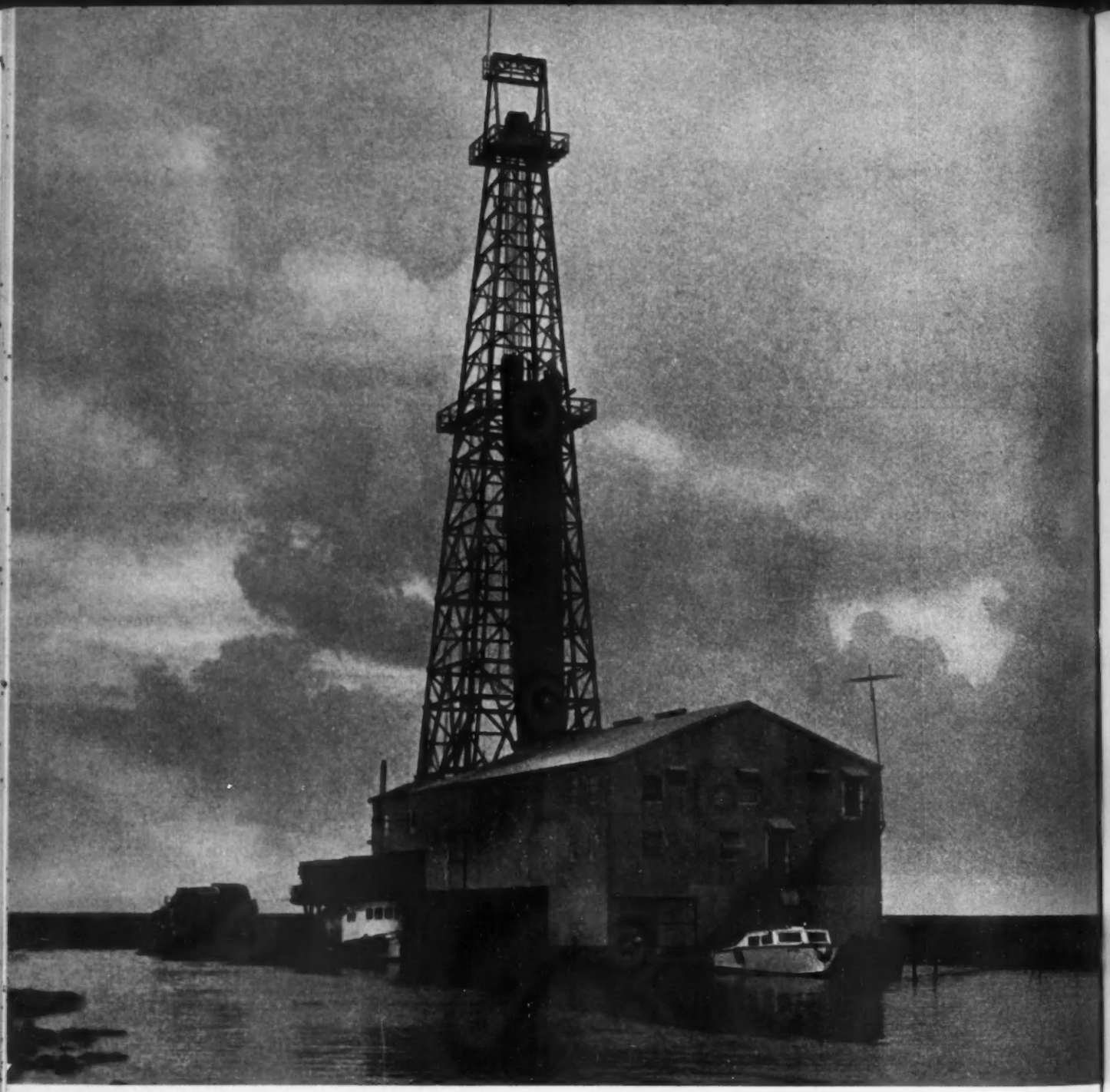
Discovery represents a new zone for Wilmington field which extends over area 1 to 2 miles wide and 3 to 4 miles long. Should current step-out drilling by offset operators prove up extensive accumulation, a sizable drilling boom might easily result.

Industry's Largest Adsorption Unit Now in Operation . . . Installed at Padre Island Texas, for Standard of Texas, the new unit is processing about 45 MMcfd at 1,000 pounds and 60 degrees. Liquid hydrocarbon recovery on initial tests approximated 120 barrels per day. Ultimately, unit will process 70 MMcfd.

Gas to unit is processed on wellhead platforms through cold separation units. With 72-inch by 15 foot adsorbing towers and 5 million Btu/hr. heater, the unit is believed to be the largest single packaged short-cycle hydrocarbon installation to date.

Diamond Bits for Down-Hole Drilling Turbines May Pay Off . . . U.S. and Western European drilling turbine manufacturers are optimistic that higher cost of diamond bits will be overcome by faster penetration rates and longer life of bits—also, less down-time in turbine drilling. Extensive experimental drilling is taking place in the United States, France and The Netherlands.

Pemex to Spend $80 Million on Expansion in '59 . . . New projects, announced by Mexico's newly appointed director general of Pemex, Pascual G. Roldan, will include completion of new refinery near Tampico; construction of gas line from Ciudad Pemex near Poza Rica to Mexico City; laying of oil and gas lines from Monterrey to Torreon and construction of three large fertilizer plants.



The BELLE CLAIRE Drills Deep. Owned by the Continental Shelf Drilling Corporation, the barge *Belle Claire* is a familiar sight in the Gulf Coast country. Here it is shown sinking a deep well at Lake De Cade, Terrebonne Parish, La. When photographed, the rig had already drilled the hole to 12,000 ft, and the crew expected to go another 4,000.

The rotary line, a Bethlehem 1⅛-in. Purple Strand rope, had been in service for almost a year. Still in excellent condition after 62,000 ft of drilling, this 6x19 line easily handled the heavy pipe and other equipment. For coring, the rig used Bethlehem 6x7 with a coating of bethanized zinc to protect against rust.

Bethlehem Steel Company, Bethlehem, Pa. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Mill depots and distributors from coast to coast stock Bethlehem rope for the following industries and numerous others:

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with AMERICAN IRON *Straight Grip* "OPEN-HOLE"® TOOL JOINTS!

ONE-THIRD LIGHTER
than any other brand tool joint!

AMERICAN IRON OPEN-HOLE Straight-Grip tool joints on light weight drill pipe average 6% lighter weight than any other tool joint and drill pipe combination! This means your rig, drilling with 6,500 feet of drill pipe, could increase the length of string to 8,400 feet by changing to light weight drill pipe with OPEN-HOLE Straight Grip tool joints.

This light weight Straight Grip tool joint has the same famous features as our regular Straight Grip. Precision machining and accurate gauging guarantee the famous 4-point seal protection against joint leakage and creep.

Increase your drilling profits by going deeper with the same drawworks. Next time, specify AMERICAN IRON Straight Grip OPEN-HOLE tool joints on your light weight drill pipe!

AMERICAN IRON OPEN-HOLE TOOL JOINTS
First and only tool joints designed specifically for use on light weight drill pipe and tubing.
AVAILABLE IN STRAIGHT GRIP, FLASH WELDED AND BUCKED-ON TYPES.

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36 Years' Experience in Designing and Manufacturing Oil Field Equipment.

AMERICAN IRON & MACHINE WORKS CO. INC. — MANUFACTURERS OF OILFIELD EQUIPMENT — A — OKLAHOMA CITY

Good Wells Make Good News

A Monthly Report on Wells That Are Now Worth More

February, 1959

Acidizing is frequently an efficient way to stimulate production from low solubility sands. Here are four recent treatments of this type by Dowell:

- **Carbon County, Wyoming** (New Oil Well) Perforations into Tensleep sandstone were from 6900 to 7000 feet. This formation exhibited about 30 per cent Mud Acid solubility. Initial production was 492 bopd through ¼-inch choke, so fracturing was not necessary. However, operator wanted to clean up bore hole, so Dowell injected a 500-gallon spearhead of Mud Acid. Then 1500 gallons of acid with surface tension reducing, demulsifying and silicate control agents completed the treatment. After clean-up, production stabilized at 1100 bopd through ¼-inch choke. The $1366.00 treatment was paid out in less than two days.

- **Avoyelles Parish, Louisiana** (Old Oil Well) This well was originally completed in the Sparta sand. Production had gradually declined to 30 bopd even though the well had been acidized several times. Dowell recommended Mud Acid to dissolve and disperse any silt that might be plugging perforations. When the well could not be loaded with oil, 25 ball sealers were dropped into the tubing to seal off the thief zone. Then 500 gallons of Mud Acid was pumped into the well, followed by 38 more ball sealers and another 500 gallons Mud Acid. Pressure increases after each injection of balls indicated that additional perforations were being reached. After treatment, production stabilized at 55 bopd. The entire treatment cost of $828.00 was paid out in eight days.

- **Hughes County, Oklahoma** (Old Oil Well) Original completion in 1924 was by nitro-shooting in the open hole. Pay is the tightly-cemented calcareous sand of the Union Valley Cromwell formation which usually responds well to acid. Dowell treated the well with two 3000-gallon stages of regular acid. A temporary plugging agent was injected between the two stages to plug off the most permeable zone. After clean-up, production stabilized at 40 bopd.

- **Hidalgo County, South Texas** (New Gas Well) This well was completed through perforations in the shaly Frio sand. Operator suspected that mud damage to formation was limiting flowing pressure. Dowell recommended acidizing with 1000 gallons super Mud Acid. After treatment, well head pressure rose from 500 to 1500 psi through ¼-inch choke. A planned fracturing treatment was considered unnecessary in view of the excellent results obtained with Mud Acid.

Dowell has the experience, the men and the chemicals needed to acidize your well successfully. For prompt service, call any of the 165 Dowell service points. In Canada, call Dowell of Canada, Ltd.; in Venezuela, United Oilwell Service. Dowell, Tulsa 1, Oklahoma.

Services for the oil industry DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

George can't do it alone

THE U.S. SENATE has received a bill which, if approved, will cut oil and gas percentage depletion from 27½ percent to 15 percent. Every individual in these United States had better hope that Congress understands what is involved here and what tampering with this 33-year old provision will mean—economically and socially, publicly and industrially. Right on down to every pocketbook.

WORLD OIL does not believe that this newest in the intermittent series of attacks on percentage depletion has any connection with President Eisenhower's statement that the Treasury Department has been asked to propose revisions aimed at removing inequities in the present tax structure. Certainly, any Treasury Department move in answer to the President would be made with the purpose of creating additional revenues for the federal government.

And if the bill now in the Senate, co-sponsored by Republican Senators Williams (Delaware), Smith (Maine) and Aiken (Virginia), should be passed in an about-face decision by Congress, it is likely that higher fuel prices paid by the federal government would more than equal any predicted increased tax revenues resulting from reduction of percentage depletion.

But that is only a part of the impact. Across the nation, all consumers would find oil products increasing in price. Defense experts in Washington would find this nation would be growing in its dependence on imported oil should an emergency arise —the worst possible time.

Why? Simply because exploratory drilling would decline, and with it would decline the amount of new oil found each year in the United States. The oil industry is aware of the certain need for the present percentage depletion rate. The industry also knows that other unhappy results would include the outright abandonment of more and more marginal operations, and a general recession in the services and supply branches of the oil industry.

The increase in products prices would be almost inevitable since the oil industry must have funds for continuing exploration programs designed to keep domestic crude oil reserves at levels required for national security.

Yes, the industry knows this because it has been plowing this allowance back into operations aimed at satisfying growing petroleum requirements.

Yes, most congressmen know this because a majority has overruled every effort to tamper with percentage depletion since its inception 33 years ago.

But the general public needs to be given the facts about percentage depletion because the decision is and should be theirs. If given the facts on a wide scale by everyone who represents any part of the oil industry, the public will choose wisely.

This calls for concerted action on an individual basis, however.

George can't do it alone.

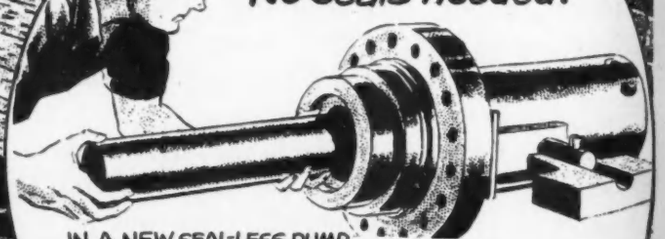
FIELD FACTS

THE METAL THAT ACTS LIKE AIR

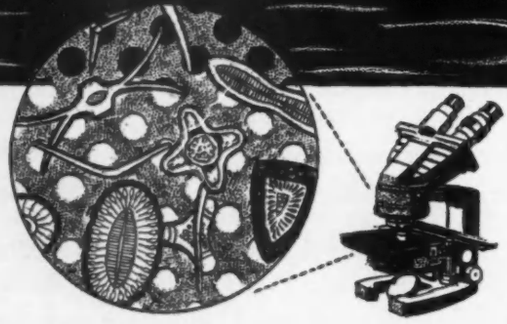
...helps driller hit 50-foot bull's-eye in longest (2.7 mile) directional hole!

LONGEST DIRECTIONAL HOLE WAS BOTTOMED 14,128 FEET UNDER HOUMA, LOUISIANA... 3,340 FEET AWAY FROM RIG. DRILLERS USED A "K" MONEL* AGE-HARDENABLE NICKEL-COPPER ALLOY COLLAR TO KEEP WITHIN 25 FEET OF PLANNED AXIS ALL THE WAY DOWN. "K" MONEL ALLOY IS NON-MAGNETIC. IN DRILL COLLARS IT ACTS AS AN AIR GAP... ISOLATES SURVEY RECORDING INSTRUMENTS FROM MAGNETIC INFLUENCES OF STRING, HELPS ASSURE TRUE DIRECTION.

Motor goes inside pump housing... No seals needed!



IN A NEW SEAL-LESS PUMP, MOTOR AND PUMP ARE COMBINED WITHIN THE SAME HOUSING. THE STATOR IS ISOLATED FROM PUMPED FLUID BY AN INCONEL* NICKEL-CHROMIUM ALLOY "SHEATH"; ROTOR BY AN INCONEL ALLOY "CAN". BECAUSE INCONEL ALLOY IS NON-MAGNETIC, THE MAGNETIC FORCE GOES RIGHT THROUGH BOTH "SHEATH" AND "CAN" TO DRIVE ROTOR WITHOUT SIGNIFICANT LOSS IN MOTOR EFFICIENCY.



0.000001-inch skeletons too "fat" to go through metal filter!

PORES IN METAL DISK OF SINTERED POWDERED METAL FILTER ARE SO TINY THAT 1-MICRON-SIZED SKELETONS OF DIATOMS (SINGLE-CELLED MICROSCOPIC, MARINE PLANTS) CAN'T BE SQUEEZED THROUGH. WHEN MADE OF POWDERED NICKEL OR STAINLESS STEEL, THESE "SOLID LOOKING" METAL FILTERS ARE ESPECIALLY USEFUL IN STRIPPING SMALL PARTICLES (POWDERED CATALYSTS, FOR EXAMPLE) FROM LIQUIDS WHEN TEMPERATURES, PRESSURES OR CORROSION ARE HIGH.

STUMPED BY A METAL PROBLEM?

A CHAT WITH INCO'S MECHANICAL OR CORROSION ENGINEERING SECTION MAY HELP. FOR DETAILED INFORMATION ON INCO NICKEL ALLOYS IN OIL PRODUCTION USES, WRITE FOR "METALS TO MAKE PETROLEUM PRODUCTION EQUIPMENT PRODUCE MORE".

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

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INCO NICKEL ALLOYS

Rising consumption improves outlook

Declining stocks presage healthier markets, if industry regulates refinery yields to avoid manufacture of too much gasoline

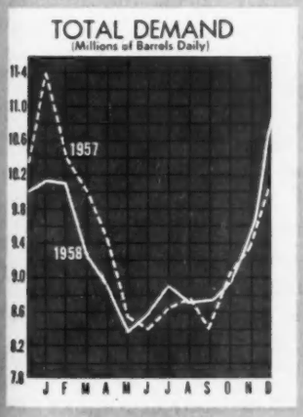
The outlook for U.S. oil in 1959 grows brighter and brighter. Colder than normal weather, coupled with general business recovery, has pushed December and January consuming rates to 11 million barrels daily, close to the all-time high reached during the Suez Canal emergency. Demand during the fourth quarter of 1958 was up 500,000 barrels a day, 5.3 percent above year ago volumes.

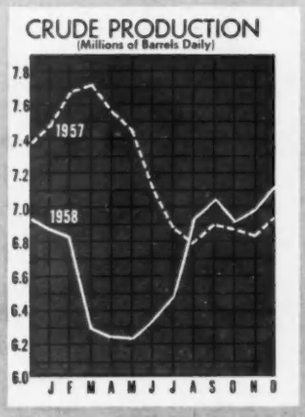
Crude stocks are at the lowest levels since 1951. Refined product inventories are lower than a year ago. Total petroleum inventories at end of December were 55 million barrels below the burdensome levels of 12 months before. Refined product stocks were down about 33 million and crude oil 22 million barrels.

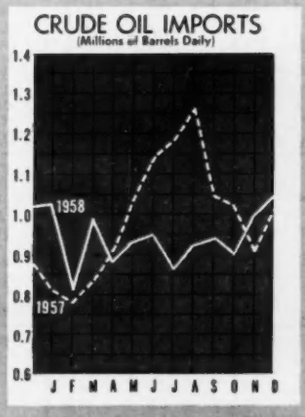
Further stock improvement was taking place during January. Continued cold weather was keeping consumption at high levels. Although sharply increased refinery runs boosted product output, distillate fuel oil stocks had dropped to 109.6 million barrels by January 18. At this level they were down nearly 50 million barrels from just one month ago, and were 26 million barrels less than a year ago. In mid-December they had been only 11.2 million barrels under levels of the previous year.

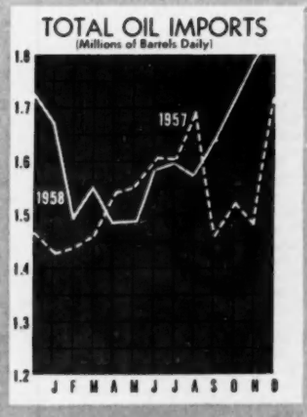
Cold weather also has caused a sharp decline in kerosine and residual fuel oil inventories. Stocks of residual in mid-January totaled 59.3 million barrels, compared with 65.7 million barrels at the end of November. Residual inventories now are only 1.4 million barrels greater than one year ago. Kerosine stocks have fallen from 31.5 million barrels at the close of

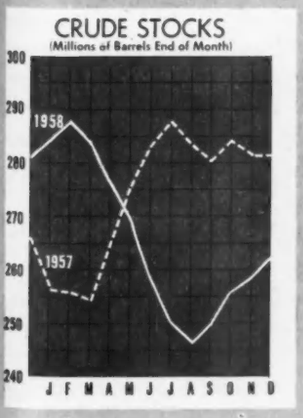
Petroleum Trends...

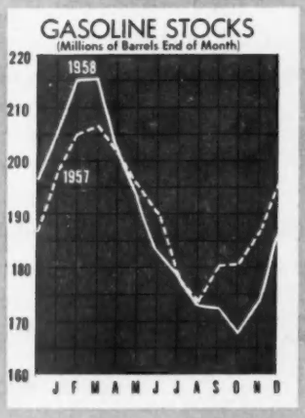


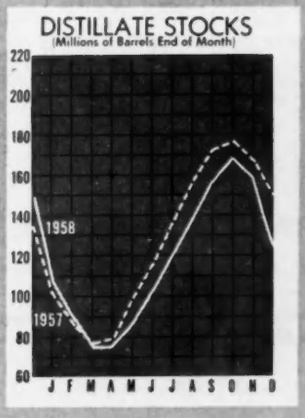


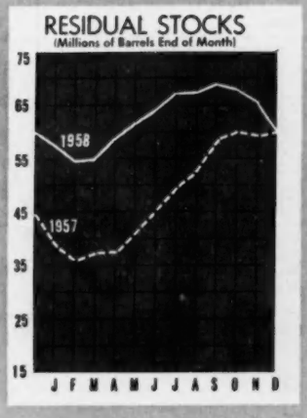












U. S. Monthly Oil Trends
(THOUSANDS OF BARRELS DAILY)

	December			Nov.	Year		
	1958	1957	% Diff.	1958	1958	1957	% Diff.
U.S. Crude Oil Production	7,105	6,929	+ 2.5	6,990	6,707	7,174	— 6.5
U.S. Nat. Gas Liquids Prod.	820	819	+ 0.1	810	790	806	— 2.0
U.S. Total Imports	1,935	1,724	+12.2	1,809	1,665	1,544	+ 7.8
East Coast Crude Imports	792	759	+ 4.3	806	768	737	+ 4.2
Total Crude Imports	1,039	1,020	+ 1.9	1,000	953	997	— 4.4
Total Refined Products	803	704	+14.1	809	704	548	+28.5
Total New Supply	9,860	9,473	+ 4.1	9,609	9,162	9,526	— 3.8
Stock Changes All Oils (Daily)	—984	—535	.....	—117	—140	+168	.....
Total Demand All U.S. Oils	10,844	10,008	+ 8.4	9,726	9,301	9,359	— 0.6
Gasoline Demand	3,786	3,703	+ 2.2	3,844	3,952	3,923	+ 0.7
Distillate Fuel Demand	3,091	2,474	+24.9	2,098	1,884	1,819	+ 1.4
Residual Fuel Demand	1,854	1,774	+ 4.5	1,493	1,487	1,589	— 6.4
Domestic Demand, All Oils	10,559	9,702	+ 8.8	9,416	9,020	8,797	+ 2.5
Export Demand, All Oils	285	306	— 6.9	310	282	562	—49.8
Crude Runs U.S. Refineries	7,956	7,816	+ 1.8	7,768	7,604	7,919	— 4.0
Domestic Crude Runs	6,952	6,880	+ 1.0	6,785	6,663	6,936	— 3.9
Foreign Crude Runs	1,004	937	+ 7.2	983	942	983	— 4.1

	TOTAL U.S. STOCKS Millions of Barrels End of Month				STOCKS EAST OF CALIFORNIA Millions of Barrels End of Month			
	December			Nov.	December			Nov.
	1958	1957	% Diff.	1958	1958	1957	% Diff.	1958
Crude Oil	262.9	281.8	— 6.7	258.1	223.6	238.9	— 6.4	220.7
Gasoline	186.2	196.8	— 5.4	173.9	160.8	168.3	— 4.5	150.6
Distillate Fuel Oil	126.7	149.4	—15.2	159.0	114.1	133.4	—14.5	145.4
Residual Fuel Oil	60.7	60.0	+ 1.2	65.7	28.5	33.4	—14.7	32.4
Kerosine	26.1	29.2	—10.6	31.5	25.7	28.8	—10.8	31.2

Source: Except for latest two months, all data from U.S. Bureau of Mines. Data for last two months from American Petroleum Institute weekly reports and U.S. Bureau of Mines weekly crude stock report; except U.S. Natural Gas Liquids Production and Demand figures which are from WORLD OIL.

U. S. Crude Production By States
(THOUSANDS OF BARRELS)

	DAILY AVERAGE PRODUCTION				TOTAL PRODUCTION		
	DECEMBER			November	YEAR		
STATE or DISTRICT	1958	1957	% Diff.	1958	1958	1957	% Diff.
Alabama	16.0	15.8	+ 1.3	16.4	5,932	5,366	+ 10.5
Arkansas	82.8	82.6	+ 0.2	79.9	28,905	30,597	— 5.5
California	854.7	927.7	— 7.9	854.9	314,604	339,668	— 7.4
Colorado	128.2	142.4	— 10.0	129.5	48,412	54,867	— 11.8
Florida	1.2	1.3	— 7.7	1.2	448	461	— 2.8
Illinois	225.6	238.4	— 5.4	223.9	82,092	78,278	+ 4.9
Indiana	32.7	34.8	— 6.0	31.9	11,757	12,859	— 8.6
Kansas	324.7	342.7	— 5.3	331.6	118,129	121,705	— 2.9
Kentucky	62.3	45.7	+ 36.3	47.5	17,262	16,879	+ 2.3
Louisiana	924.9	836.6	+ 10.6	918.9	312,086	323,199	— 3.4
North Louisiana	114.2	118.7	— 3.8	113.8	41,721	46,127	— 9.6
South Louisiana	810.7	717.9	+ 12.9	805.1	270,365	277,072	— 2.4
Michigan	24.8	26.1	— 5.0	24.8	9,237	10,169	— 9.2
Mississippi	119.6	95.0	+ 25.9	120.4	38,618	39,202	— 1.5
Missouri-Tennessee-South Dakota	0.3	0.4	— 25.0	0.3	127	112	+ 13.4
Montana	76.8	77.6	— 1.0	77.6	28,255	27,215	+ 3.8
Nebraska	59.8	59.1	+ 1.2	59.3	20,524	19,586	+ 4.8
Nevada-Washington	0.1	0.1	.....	0.1	42	27	+ 55.6
New Mexico	279.6	265.5	+ 5.3	279.5	98,467	94,759	+ 3.9
Southeast New Mexico	250.2	255.5	— 2.1	252.0	90,286	92,240	— 2.1
Northwest New Mexico	29.4	10.0	+194.0	27.5	8,181	2,519	+224.8
New York	4.6	7.0	— 34.3	5.2	1,797	2,677	— 32.9
North Dakota	38.9	39.2	— 0.8	33.9	13,736	13,642	+ 0.7
Ohio	14.2	16.8	— 15.5	16.0	6,202	5,116	+ 21.2
Oklahoma	552.1	583.1	— 5.3	559.0	202,505	215,111	— 5.9
Pennsylvania	16.0	20.1	— 20.4	16.3	6,680	8,179	— 18.3
Texas	2,835.2	2,748.9	+ 3.1	2,744.4	940,191	1,085,918	— 13.4
Dist. 1: South Central	46.3	50.2	— 7.8	47.5	16,883	19,464	— 13.3
Dist. 2: Middle Gulf	129.6	130.4	— 0.6	125.1	42,426	52,976	— 19.9
Dist. 3: Upper Gulf	414.5	408.7	+ 1.4	393.6	137,854	160,775	— 14.3
Dist. 4: Lower Gulf	205.5	203.6	+ 0.9	203.6	69,542	82,567	— 15.8
Dist. 5: East Central	31.2	31.3	— 0.3	30.4	10,966	3,775	+190.5
Dist. 6: Northeast	287.8	276.1	+ 4.2	277.3	94,668	116,849	— 19.0
Dist. 7-B: North Central	141.0	144.2	— 2.2	138.3	49,987	57,341	— 12.8
Dist. 7-C: West Central	142.9	155.0	— 7.8	144.7	48,776	58,468	— 16.6
Dist. 8: West	1,116.6	1,009.5	+ 10.6	1,072.6	349,680	400,461	— 12.7
Dist. 9: North	216.9	205.9	+ 5.3	209.3	73,288	76,286	— 3.9
Dist. 10: Panhandle	103.8	103.7	+ 0.1	102.0	36,688	37,251	— 1.5
Utah	89.5	16.7	+435.9	77.8	24,420	4,093	+496.6
Virginia	.....	.....	.....	.....	7	6	+ 16.7
West Virginia	5.3	6.0	— 11.7	6.1	2,189	2,215	— 1.2
Wyoming	335.3	299.2	+ 12.1	330.8	115,453	106,616	+ 8.3

Source: Bureau of Mines and API. Texas districts from API and do not necessarily agree with State totals.

November to 23.2 million in mid-January. They now are 2 million barrels below year ago levels.

Gasoline inventories, of course, are rising under the double stimulation of cold weather curtailing demand while high refinery runs boosted production. However they are still in good statistical position. In totaling 190.7 million barrels in mid-January, up almost 17 million barrels from the end of November, they still were 10 million barrels below year-ago levels.

Increased U.S. Producing Rates are presaged by higher consumption, reduced stocks, and enlarged refinery runs. Despite the high level of imports, which have been at record levels in recent months due to greater refined product imports, present conditions indicate U.S. producers can look forward to somewhat larger producing rates. This would be in marked contrast to the drastic cutbacks that took place in the spring and summer months of 1958.

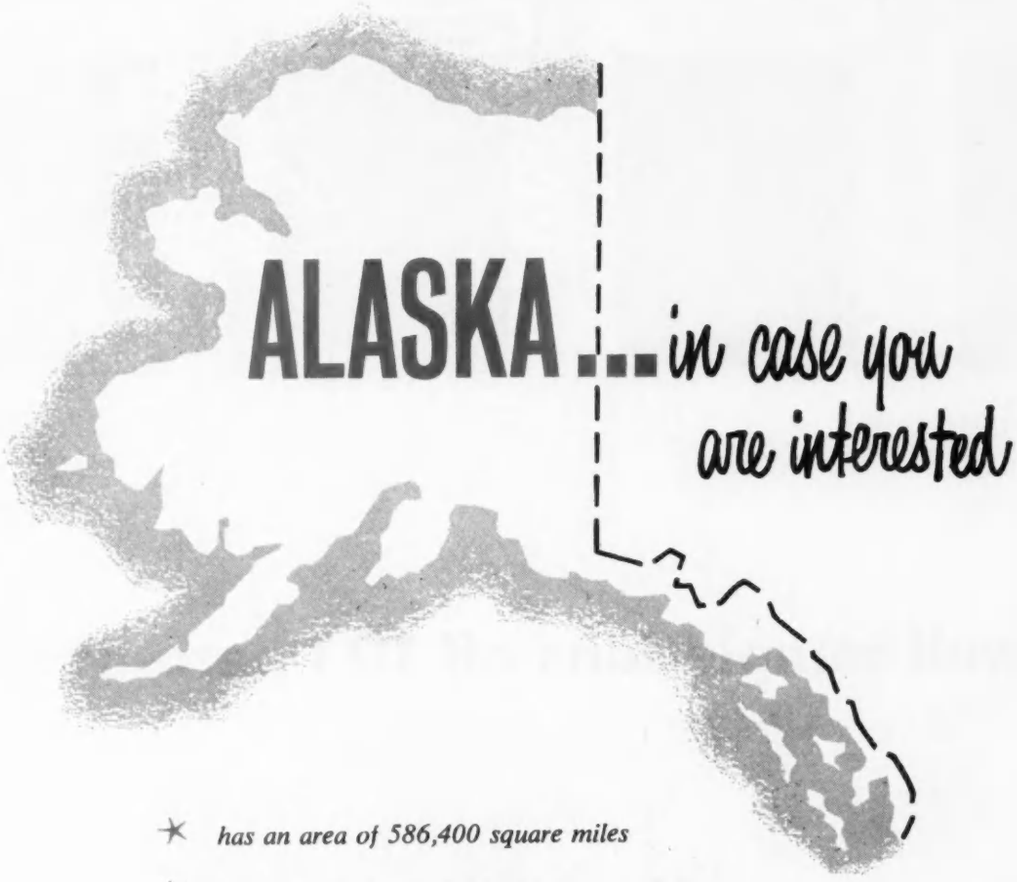
During the first half of 1959, U.S. crude production could average a little over 7 million barrels daily with out damaging the industry's statistical position. This would be a marked improvement over 1958, when production fell below 6.3 million a day during three consecutive months.

If the government imposes restrictions which check the upward rise of refined product imports, U.S. production can be advanced to even higher levels.

The chief danger is the possibility that higher refinery runs to meet heating oil needs will result in the manufacture of too much motor fuel. Excessive gasoline inventories would be exceedingly harmful. They would certainly lead to price weaknesses, just when it appears the industry has a good chance to see prices stabilize, and perhaps recover some of the ground lost during the past year.

If this occurs, it will be the industry's own fault. High refinery runs need not produce excessive quantities of gasoline. Refinery yields can, and must, be adjusted to increase the output of distillate and reduce the output of gasoline.

Otherwise, the industry will be cutting its own throat, just when it has recovered from serious difficulties.



ALASKA ... *in case you are interested*

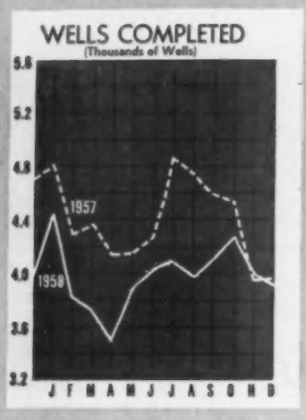
- *has an area of 586,400 square miles*
- *has at least nine possible petroleum provinces*
- *has the highest peak in North America (Mt. McKinley, 20,257')*
- *was discovered by a Dane, Vitus Bering, in 1741*
- *has a 6,640-mile coastline*
- *has, as its approximate geographic center, a point in latitude 63° 46', longitude 152° 20'*
- *has produced some oil since the early 1900's*
- *has, as its state flower, the Forget-me-not,*

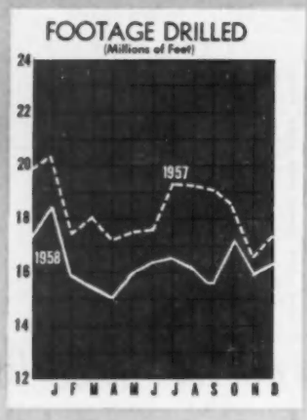
A **HOT** item to remember is GSI experience in **COLD** climates . . . in Alaska and above and below the Arctic Circle in Canada. You can lessen the tough going in Alaska by discussing your seismic, gravity and magnetic exploration programs with GSI.

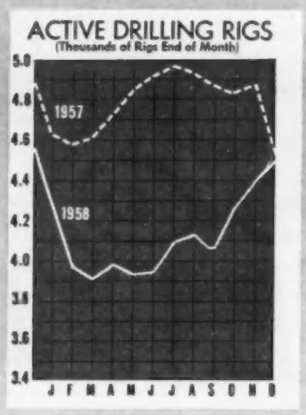
GEOPHYSICAL SERVICE INC.

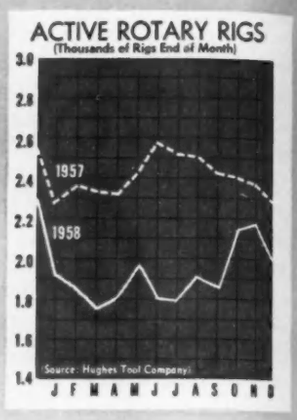
900 EXCHANGE BANK BUILDING • DALLAS 35, TEXAS

Drilling Activities...









Year's well completions off 10.1 percent

TIGHTENED PRORATION schedules, excessive imports and the recession combined to drop 1958 new U.S. well completions 10.1 percent below the 1957 total. New well completions totaled 48,331 in 1958—a decline of 5,452 wells from the previous 12-month period.

The 1958 total was less than 1 percent (379 wells) greater than WORLD OIL's mid-year forecast of 47,952 wells.

December's new well completions failed to exceed the 4,000-well rate for the first time in six months, probably because cold weather delayed drilling progress in many areas. New completions reported for December totaled 3,949, or 57 wells less than the 4,006 completions recorded in November and 395 less than the 4,344 completions accounted for in October. Although the December total was below the last half average, it still was considerably higher than the year's low of 3,553 wells in April.

Operators drilled 195.8 million feet of hole last year, 25.1 million feet or 11.4 percent less than was drilled in 1957.

Summary of U.S. Drilling Activity

ITEM	Dec. 1958	Nov. 1958	TWELVE MONTHS YEAR 1958	1957	% Diff.
New Wells Completed:					
Oil	1,946	1,957	23,774	27,519	—13.6
Distillate	43	52	710	743	— 4.4
Gas	373	372	4,295	3,879	+10.7
Service	93	1,521	1,390	1,392	— 0.1
Dry	1,494	104	18,162	20,250	—10.3
Total Wells	**3,949**	**4,006**	**48,331**	**53,783**	**—10.1**
Footage Drilled (Mln. of Feet)	**16.2**	**15.9**	**195.8**	**220.9**	**—11.4**

Summary of U.S. Wildcat Drilling

ITEM	Dec. 1958	Nov. 1958	TWELVE MONTHS YEAR 1958	1957	% Diff.
New Field Discoveries:					
Oil	65	71	743	848	—12.4
Distillate	...	4	80	120	—33.3
Gas	16	12	220	213	+ 3.3
Total Discoveries	**81**	**87**	**1,043**	**1,181**	**—11.7**
Dry Wildcats	727	743	8,731	10,228	—14.6
Total Wildcats	**808**	**830**	**9,774**	**11,409**	**—14.3**
Percent Productive	10.0	10.5	10.7	10.4	....
Percent Dry	90.0	89.5	89.3	89.6	....

Details on Page 30

ADDITIONAL DATA: *Improved Cages*

MARTIN RUBBER GUIDE CAGES BY

PAT. NO. 2,591,174

Metallic back-stop is now available in Closed Type Cages by use of 18-8 insert in upper part of rubber guide. Ball never touches this metal in normal pumping.

Metallic back-stop is now provided in Open Type Cages by leaving cross bar above primary ball stop position. Ball never touches this metal in normal pumping.

THE WORLD'S MOST SUCCESSFUL
NOW EVEN BETTER!

The Martin Rubber Guide Idea, which has proven successful beyond anyone's expectation, is now available in improved form. The primary rubber ball stop for normal operation is now backed up by a metal stop to take the unusual ball impact which sometimes occurs.

Easily replaceable, mechanically held rubber guides often permit the renewal of cage life several times. They outlast metal by a great margin and usually increase ball and seat life two or more times.

Many production men specify MARTIN CAGES in all their pumps. Our cages are available in all sizes and types to take care of anyone's requirements.

JOHN N. MARTIN

Manufacturer

9 W. BRADY STREET • TULSA, OKLAHOMA

U. S. Drilling Activity in December and Years 1958-1957

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED: DETAILS FOR DECEMBER, 1958					TOTAL NEW WELLS			Total Footage December 1958	DETAILS FOR YEARS 1958-1957: NEW WELLS			DETAILS FOR YEARS 1958-1957: FOOTAGE		WILDCAT DRILLING IN YEARS 1958-1957: DETAILS FOR DEC., 1958					DETAILS FOR YEAR					DRILLING RIGS IN OPERATION (Rigging Up, Drilling, Temp. Shut Down)		
	Oil	Dist.	Gas	Dry	Serv-ice Wells	Dec. 1958	Nov. 1958	Dec. 1957		1958	1957	Percent Diff.	1958	1957	Oil	Dist.	Gas	Dry	Total Wild-cats	Oil	Dist.	Gas	Dry	TOTAL WILDCATS 1958	TOTAL WILDCATS 1957	Dec. 31 1958	Nov. 30 1958	Dec. 31 1957
Alabama	4	....	....	7	....	11	5	6	76,126	85	94	— 9.6	686,232	790,240	....	....	....	6	6	1	....	....	32	33	41	15	18	11
Arkansas	62	....	3	36	....	101	80	88	340,804	852	1,104	— 22.8	2,848,849	3,371,923	1	....	....	19	20	8	3	7	146	164	184	52	43	46
California	76	....	6	43	4	129	99	205	639,585	1,367	2,303	— 40.7	6,670,035	9,899,891	1	....	....	32	33	9	....	3	270	282	388	156	142	168
Colorado	10	....	2	49	....	61	70	70	329,419	850	815	+ 4.3	4,412,384	4,267,074	2	....	....	29	31	28	....	16	429	473	483	60	59	56
Florida	....	....	....	1	....	1	....	1	11,898	7	9	— 22.2	67,707	61,732	....	....	....	1	1	....	....	....	7	7	9	1	1	1
Georgia	....	....	....	....	....	....	....	....	....	1	5	— 80.0	2,915	25,712	....	....	....	....	....	....	....	....	1	1	5	1	....	....
Illinois	47	....	2	68	1	118	287	124	264,311	2,302	2,590	— 11.1	5,273,689	5,928,958	....	....	....	34	34	6	....	1	582	589	736	294	306	268
Indiana	25	....	....	48	....	73	99	69	119,876	882	718	— 22.8	1,424,712	1,211,411	....	....	....	18	18	10	....	1	238	249	168	113	112	117
Kansas	144	....	21	173	6	344	337	409	1,220,004	3,759	4,222	— 11.0	12,981,318	14,995,879	16	....	....	79	95	127	....	24	841	992	1,005	338	327	515
Kentucky	49	....	15	72	....	136	129	120	204,136	1,812	1,849	— 2.0	3,136,144	2,539,569	....	....	....	2	2	10	....	2	63	75	132	95	107	86
Louisiana	150	10	17	127	....	304	311	291	2,361,262	3,508	3,772	— 7.0	27,066,565	29,746,194	1	....	1	65	67	33	20	8	546	607	637	356	374	381
North Louisiana	54	....	8	59	....	121	142	113	482,856	1,389	1,433	— 3.1	5,171,217	5,234,383	1	....	....	35	36	16	....	....	211	227	201	65	75	82
South Louisiana	96	10	9	68	....	183	169	178	1,878,406	2,119	2,339	— 9.4	21,895,348	24,511,811	....	....	1	30	31	17	20	8	335	380	436	291	299	299
*Gulf of Mexico	20	4	4	8	....	36	33	45	374,692	487	648	— 24.9	4,702,522	6,176,558	....	....	1	1	2	3	1	3	33	40	69	44	42	69
Michigan	15	....	5	16	....	36	36	52	103,056	392	419	— 6.5	1,123,455	1,196,801	1	....	....	8	9	8	....	4	119	131	150	86	84	66
Mississippi	16	1	1	46	....	64	40	30	424,734	428	390	+ 9.7	3,641,127	2,897,555	1	....	1	18	20	11	1	1	148	161	188	75	71	44
Missouri	....	....	1	....	....	1	....	....	555	16	10	+ 60.0	16,167	7,647	....	....	1	....	1	....	....	1	8	9	10	....	3	....
Montana	14	....	....	11	....	25	28	37	136,244	306	429	— 28.7	1,607,096	2,143,462	2	....	....	8	10	9	1	5	104	119	172	39	59	42
Nebraska	15	....	....	43	....	58	71	75	349,694	697	893	— 22.0	4,163,621	5,297,998	2	....	....	28	30	34	....	....	294	328	451	30	27	27
Nevada	....	....	....	....	....	....	....	....	....	....	5	—100.0	....	11,260	....	....	....	....	....	....	....	....	....	....	5	....	....	1
New Mexico	65	....	54	22	....	141	170	145	562,457	1,970	2,192	— 10.1	9,107,964	10,354,453	2	....	....	13	15	36	2	17	220	275	297	154	162	175
Southeast	40	....	2	15	....	57	80	85	280,816	969	1,304	— 25.7	4,835,379	6,598,283	2	....	....	10	12	26	2	4	147	179	191	83	73	95
Northwest	25	....	52	7	....	84	90	60	281,641	1,001	888	+ 12.7	4,272,585	3,756,170	....	....	....	3	3	10	....	13	73	96	106	71	89	80
New York	24	....	1	2	18	45	45	48	53,400	540	530	+ 1.9	640,800	620,676	....	....	....	....	....	....	....	....	....	....	17	42	42	46
North Dakota	15	....	....	8	....	23	30	49	147,405	408	312	+ 30.8	2,642,398	2,120,326	....	....	....	5	5	21	....	....	99	120	148	34	28	45
Ohio	37	....	22	23	....	82	88	73	235,557	988	1,011	— 2.3	2,582,097	2,423,755	....	....	....	3	3	....	....	....	13	13	9	228	218	203
Oklahoma	308	2	45	192	41	588	504	299	1,881,614	7,047	5,663	+ 24.4	21,963,621	19,419,287	5	....	4	58	67	72	11	36	651	770	659	529	547	585
Pennsylvania	20	....	36	13	8	77	71	109	259,207	793	1,125	— 29.5	2,394,409	3,635,350	....	....	....	1	1	....	....	4	23	27	14	210	213	140
South Dakota	1	....	....	....	....	1	....	....	6,845	7	41	— 82.9	33,649	140,675	1	....	....	....	1	1	....	....	6	7	39	3	2	2
Tennessee	....	....	....	5	....	5	5	....	6,550	30	32	— 6.3	37,650	39,804	....	....	....	2	2	....	....	....	12	12	24	....	....	....
Texas	779	30	81	438	15	1,343	1,329	1,510	5,748,110	17,283	21,290	— 18.8	73,280,859	90,102,965	28	....	8	265	301	306	42	85	3,536	3,969	5,025	1,181	1,093	1,230
Dist. 1: South Central	72	8	3	24	....	107	64	84	297,847	988	1,255	— 21.3	2,451,870	3,253,106	....	....	....	19	19	10	1	2	301	314	372	36	38	37
Dist. 2: Middle Gulf	19	8	3	26	....	56	53	52	340,353	699	760	— 8.0	4,280,900	4,607,353	....	....	....	20	20	11	8	11	217	247	266	52	32	36
Dist. 3: Upper Gulf	47	7	15	54	....	123	99	117	821,430	1,295	1,644	— 21.2	8,366,026	10,763,881	2	....	1	30	33	12	6	11	325	354	435	113	107	109
*Gulf of Mexico	....	....	....	....	....	....	....	....	....	11	10	+ 10.0	86,748	76,651	....	....	....	....	....	1	....	1	7	9	5	....	....	1
Dist. 4: Lower Gulf-S.W.	32	7	4	55	....	98	66	123	513,909	1,128	1,426	— 20.9	5,861,401	7,531,685	6	....	2	43	51	26	11	9	417	463	463	85	87	77
*Gulf of Mexico	....	....	....	....	....	....	1	2	....	8	22	— 63.6	84,048	216,750	....	....	....	....	....	....	....	....	3	3	4	....	....	1
Dist. 5: East Central	6	....	1	8	....	15	13	27	59,895	194	180	+ 7.8	736,388	775,682	....	....	....	7	7	3	2	1	105	111	133	14	16	11
Dist. 6: Northeast	42	....	5	26	....	73	71	86	404,777	839	1,069	— 21.5	4,502,167	5,811,496	1	....	1	19	21	8	5	4	194	211	262	58	58	60
Dist. 7-B: North Central	73	....	8	69	2	152	161	173	480,090	2,132	2,664	— 20.0	6,781,123	8,847,789	6	....	1	45	52	77	3	9	669	758	1,006	84	93	111
Dist. 7-C: West Central	22	....	4	15	....	41	50	68	203,473	748	1,155	— 35.2	3,650,065	5,396,822	2	....	....	11	13	29	....	8	177	214	325	68	57	77
Dist. 8: West	283	....	10	56	5	354	316	438	1,700,427	4,212	5,047	— 16.6	20,439,103	24,723,460	8	....	3	30	41	80	1	9	432	522	551	387	369	368
Dist. 9: North	135	....	5	100	8	248	321	233	634,538	3,742	4,640	— 19.4	10,542,486	12,490,756	....	....	....	40	40	35	2	6	601	644	1,056	189	146	227
Dist. 10: Panhandle	48	....	23	5	....	76	115	109	291,371	1,306	1,450	— 9.9	5,669,330	5,900,935	3	....	....	1	4	15	3	15	98	131	156	95	90	117
Utah	12	....	13	....	....	25	24	36	136,026	395	285	+ 38.6	2,189,909	1,563,758	....	....	....	9	9	....	....	....	87	87	115	36	39	64
Washington	....	....	....	1	....	1	....	....	7,353	7	4	+ 75.0	40,635	20,459	....	....	....	1	1	....	....	....	6	6	3	1	1	1
West Virginia	27	....	39	7	....	73	71	57	195,239	836	832	+ 0.5	2,239,102	2,237,427	....	....	....	....	....	....	....	....	6	6	10	219	213	168
Wyoming	31	....	5	38	....	74	65	73	322,961	711	813	— 12.6	3,326,345	3,664,736	2	....	1	20	23	13	....	4	206	223	277	93	115	75
Others	....	....	4	5	....	9	12	....	46,878	52	26	+100.0	228,488	126,599	....	....	....	3	3	....	....	1	26	27	8	4	4	6
Total United States	1,946	43	373	1,494	93	3,949	4,006	3,974	16,191,306	48,331	53,783	— 10.1	195,829,942	220,863,576	65	....	16	727	808	743	80	220	8,719	9,762	11,409	4,445	4,410	4,569
Total Western Canada	125	....	20	55	7	207	199	179	1,024,650	2,557	2,993	— 14.6	12,683,921	13,968,509	....	....	....	....	....	....	....	....	....	....	....	243	219	177

* Gulf of Mexico wells are included in their respective district total.

More savings in the hole when your drilling pipe goes through mud that has the low fluid loss and high suspension advantages of Du Pont CMC.

Du Pont CMC in the mud can save dollars in the hole

Will you be the next operator to discover this easy way to dollars-per-foot savings?

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Provides Good Suspension. Du Pont CMC has excellent suspending power, and a small amount can effectively replace a large amount of low gravity clay solids for suspending barite in high weight muds.

Resists Contamination. Du Pont CMC acts as a protective colloid, guards your muds from contaminating effects of salt, gyp or anhydrite formations.

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These are good dollars-and-cents reasons for you to improve your drilling muds *now* with Du Pont CMC Grade DM. Order it from your local mud dealer, or contact:

- **Barada & Page, Inc., offices in Corpus Christi, Dallas, Fort Worth, Houston, Kansas City, New Orleans, Odessa, Oklahoma City, Tulsa, Wichita.**
- **Macco Corp., Paramount, California.**
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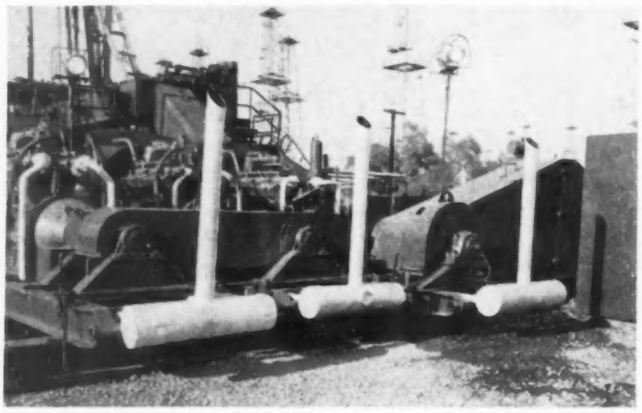
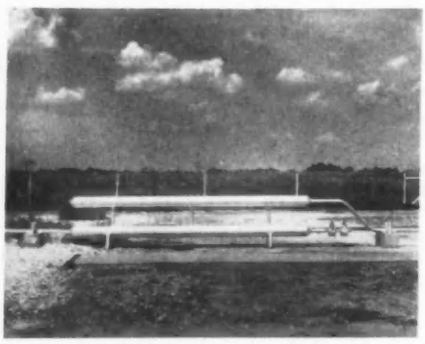
Exhaust Manifolding in Skid Base Will Save Rigging Up Costs



Installing the exhaust manifolds beneath the engine and compound skid-bases can save time and effort during moving operations. In the installation shown, the exhaust line for each bank of the V-type engine is brought straight down into the skid base, then out to the end where it terminates in the base-level muffler and short vertical exhaust riser. Putting the riser at this point carries exhaust gases somewhat farther away from the well and, during moving operations, the compact unitized installation means fewer brackets to install and simplified loading on trucks. Also, since the manifold system need not be disassembled each time there is less likelihood of damage occurring to those more fragile and easily dented units.



Horizontal Sand Trap Easily Constructed

This high pressure, double barreled sand trap can be constructed in the field with a minimum of time and effort. The unit shown in the photograph is used on a gas well and operates at approximately 3,000 psi pressure.

Each of the large horizontal sections is made from discarded (cut sections) pieces of 7-inch O.D. casing. The three connecting lines between the 7-inch sections are made from 2½-inch tubing. The inlet, outlet and drain connections are all 2½ inches. As indicated, the 7-inch pipe is orange peeled and sealed on each end. This unit was designed to operate at wellhead pressure.

Well fluid enters the lower section of 7-inch casing through the 2½-inch inlet shown at the left. Fluid then must rise through the three vertical sections of 2½-inch connecting pipe to the top section of the 7-inch. The fluid then passes out of the trap through the 2½-inch outlet shown at the right. Sand drops out of the well stream as it rises from the lower section of the trap to the upper portion. Since the well is being choked downstream of the trap, the well stream has a relatively low velocity in the trap proper. This increases the ability of the sand to separate from the well stream.

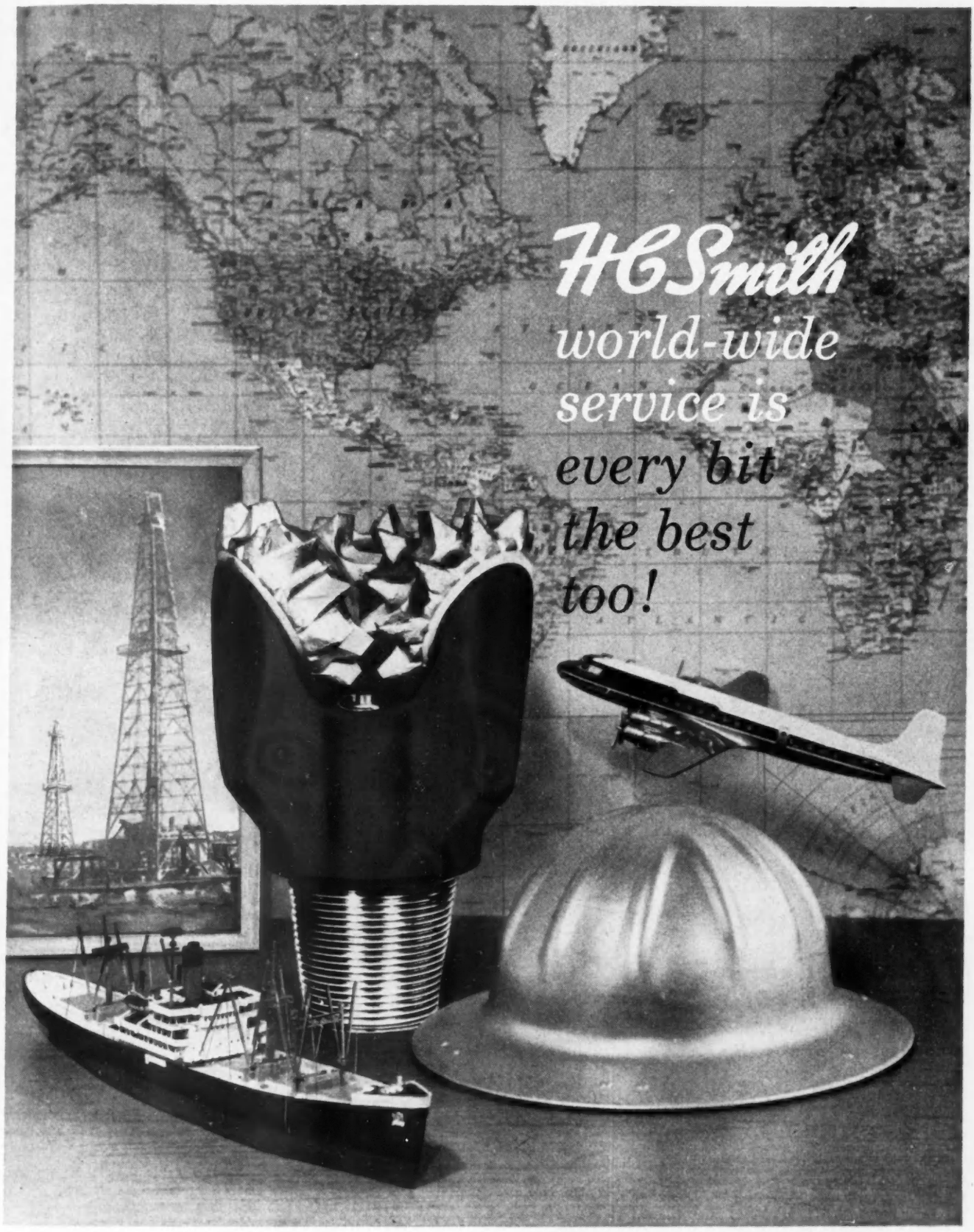
After sand has accumulated for a time, the trap can be cleaned by opening the bleed line shown at the lower right on the lower section of 7-inch casing. Since this bleed line is open ended, well pressure tends to discharge any accumulated sand from the vessel.

Platform Keeps Pump Above Flood Water

In areas subject to sudden, destructive floods, pumps on shallow oil wells can be mounted on a steel platform, the floor of which is 20 feet or more above the surface of the ground. This well, located in the Ohio River Valley of West Virginia, has its pump safely placed above high water which frequents the bottom lands.

Make Connecting Table And Mud Hopper Portable

For the convenience of the crew who add sacked mud products to the mud system, one tool pusher had a rig-built table hooked directly on the rig-built mud hopper. He then had the mud hopper and table combination skid-mounted for easier moving.



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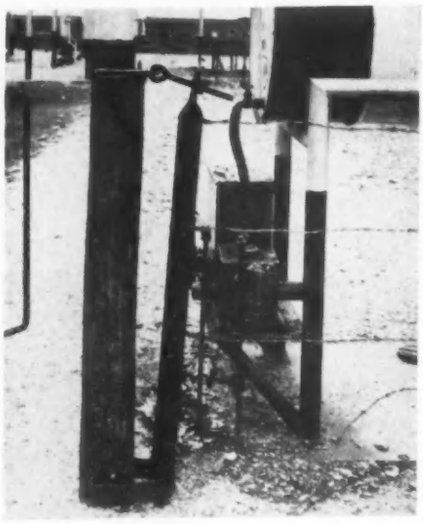
Prefabricated Racks Protect Hydraulic Lines

Hydraulic lines are very expensive and unless properly stored are very easily lost or mishandled. One contractor in Canada uses prefabricated racks on the side of the building for this purpose.

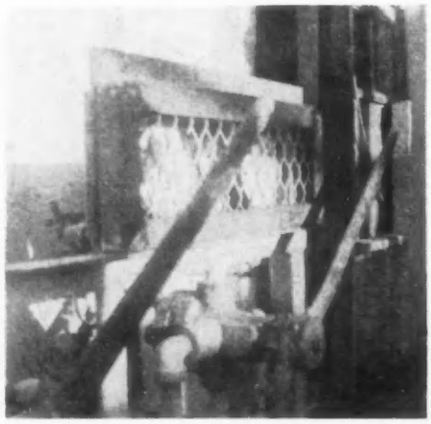


Make Removable Fence Gap With Steel Fence Post

The steel fence post illustrated is installed on the "road" side of a tank battery providing a removable fence gap. The adjustable post is equipped with a slotted piece of steel at the upper end so that the eye bolt shown can be easily attached to the top portion. In the loose position shown the portion of the fence attached to the post is easily removed to allow trucks to enter the confines of the battery proper.

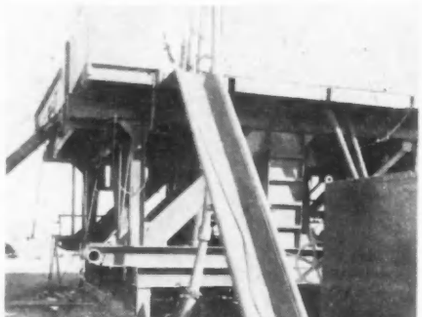
The post is constructed of a piece of junk 2-inch pipe. The strap attached to the bottom portion of the gate post retains the bottom of the steel post in the proper position. The top piece of steel plate (to which the eye bolt is attached) is nailed on the top part of the gate post.

If a neat, permanent installation is required, the nut on the eye bolt is tightened until the desired tension is obtained in the barbed wire. The gap is easily constructed and provides a quick cheap method of installing a wide battery gate for vehicles.



Simple Cover Protects Blowout Preventer Gages

Blowout preventer gages are very important and must be protected against breakage or mishandling. The enclosed picture shows a gage cover that has been made out of angle iron and wire mesh to accomplish this purpose.



Chute Speeds Loading Of Small, Heavy Tools

An inexpensive tool ramp that provides certain advantages, particularly in the loading and unloading of small but very heavy tools, can be built economically out of a longitudinally-split piece of 16-inch casing. Reinforced by two lengths of drill pipe to give it longitudinal strength, the chute rests at about a 45-degree angle against the side of the rig, as illustrated.

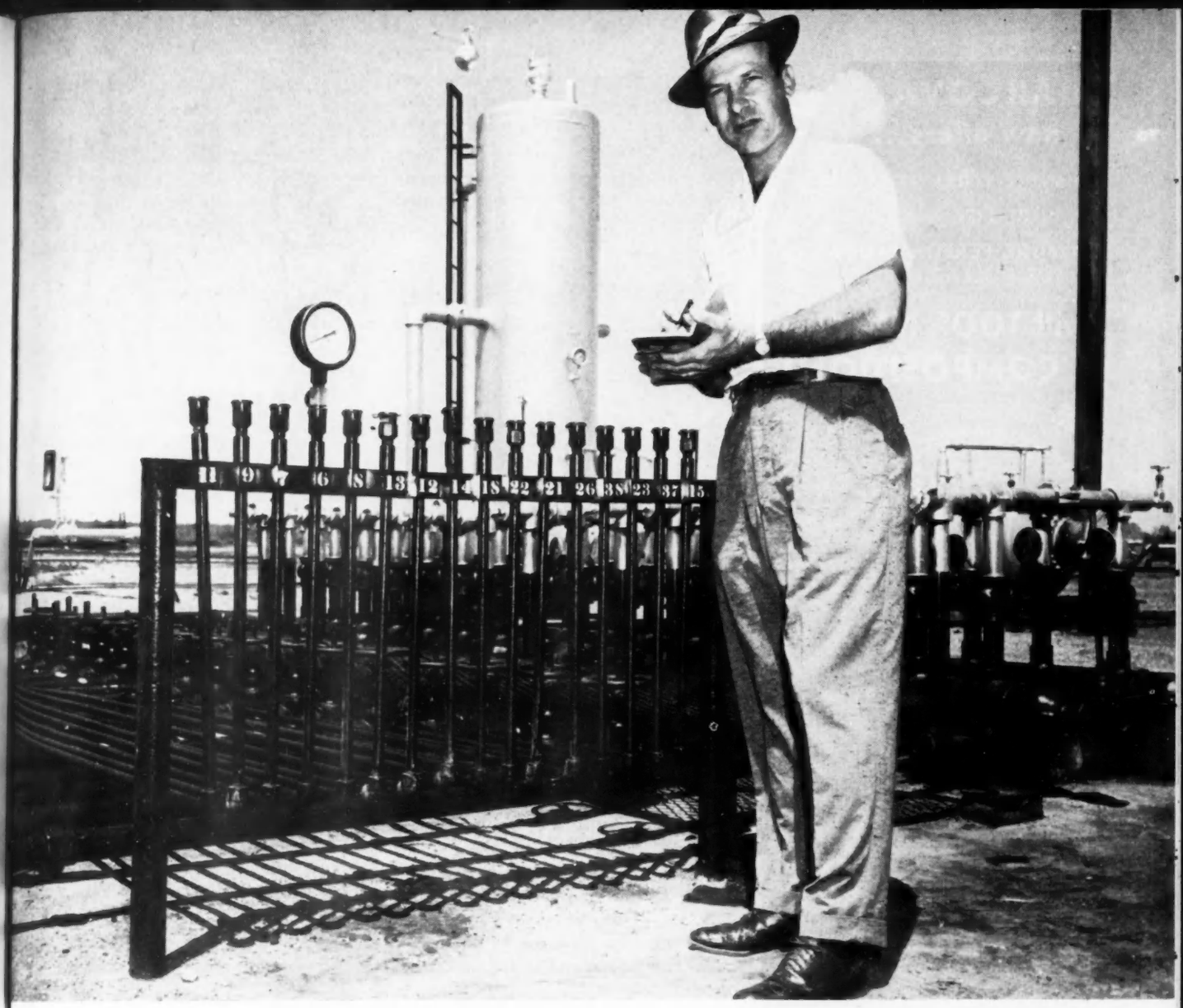
It is particularly useful and convenient when handling large bits, reamers, subs and similar equipment. Usually, such items can be handled with far less effort and "jockeying" by crewmembers and with less chance of a man becoming hurt or a tool getting away while being lifted or lowered. Backing the truck up to the ramp enables the quick, easy transfer without the two-stage handling as is necessary with the conventional dock.

In the installation shown, a small amount of concrete was poured on the ground at the base of the chute, this to keep tools from "ploughing" into the soft ground or mud should it be lowered to ground level.

Ladder Built From Scrap Saves Time

It is hard to figure out why more accidents don't occur around some drilling rigs. Many times you have to be part monkey to work on some pieces of equipment or to just get around a rig. For instance how many times have you climbed over steam laden pipes to get from the boilers to the mud hopper? One contractor who must have gotten burned himself, had this ladder built so he and his crews could ascend from the ground level to the chemical barrel. The best thing about the ladder is that the only cost was a little of the welders time.

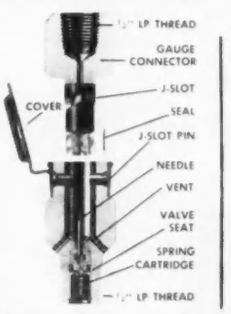
It was constructed from the following scrap material: 4 long and 4 short pieces of angle iron; 5 pieces of sheet metal; and 2 lengths of sucker rod. The angle irons welded together in a rectangular frame formed the ladder supports; the 5 pieces of sheet metal welded to the supports formed the



You Can Stand In One Spot And Gauge Sixteen Wells . . . With One Pressure Gauge . . . in 10 minutes!

It's no trick, and you can do it. Pictured above is a 16-well manifold at a central lease tank battery. Instead of separate pressure gauges for each well, the manifold is equipped with T-C Gauge Valves. A single pressure gauge, with a T-C Connector attached, is stabbed into each Gauge Valve to obtain a pressure reading. Just insert the connector in the valve, rotate 45 degrees, the valve opens automatically, and that's all.

For individual wells, instead of installing permanent gauges on tubing and casing, many operators are now using T-C Gauge Valves and Connectors. The first cost is lower, there's no gauge breakage—gauge repair costs are eliminated—and since the gauges are not exposed to the elements, you can be sure of accurate pressure readings.



Cross-section view of Gauge Valve and Connector.

The Gauge Valve and Connector is widely used on Christmas trees.

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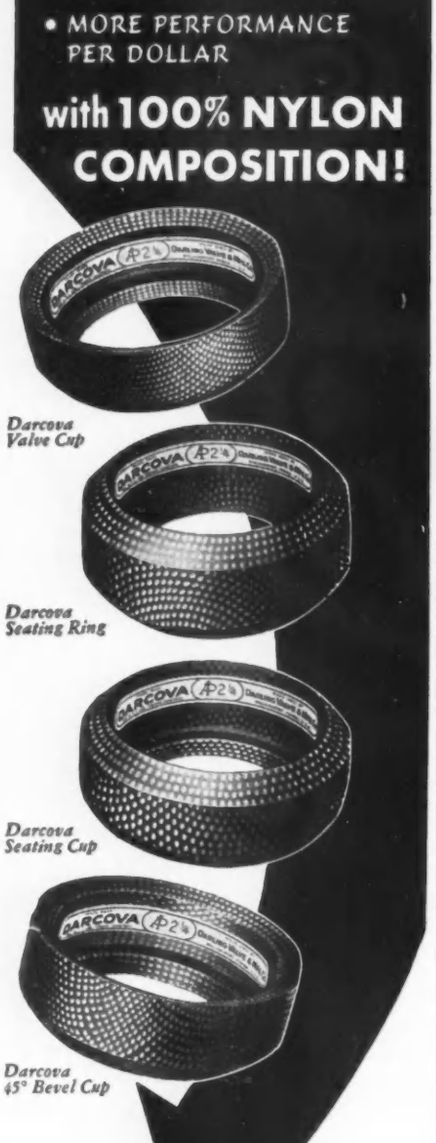

Darcova Valve Cup

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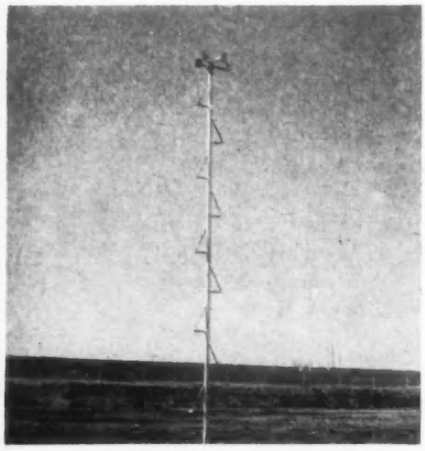
THE ORIGINAL COMPOSITION CUP

steps and the sucker rods bent and welded to the frames made the hand rails for safer ups and downs.

This rig-built ladder not only dresses up a rig but can save money by avoiding lost-time accidents caused by falls.



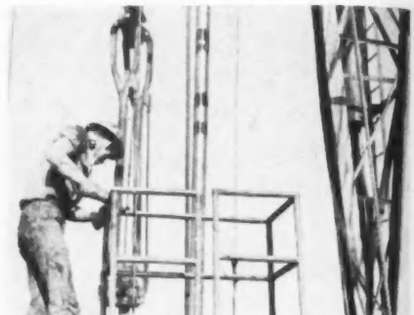
Light Pole Fabricated From Scrap Material

For appearance, safety and effective lighting around a tank battery or other permanent installation, the light pole in this illustration is hard to beat. The pole is 2-inch steel pipe with a junction box mounted at the top. Flood lights are attached to the box and the wiring is run down the inside of the pipe to a second box at the base. The switch can be located either on this pole at the junction box, or the cable can be run under ground to a central lighting switch that would flood the entire area.

To make the lights readily acceptable for changing, steps of reinforcing rods have been welded to the pole. The reinforcing rod was bent into an angular shape and welded to the pole as shown in the photograph. This provides added security over the conventional spike type of step in that the climber's foot can not slip off the end. This method also provides ample hand grips for the climber.

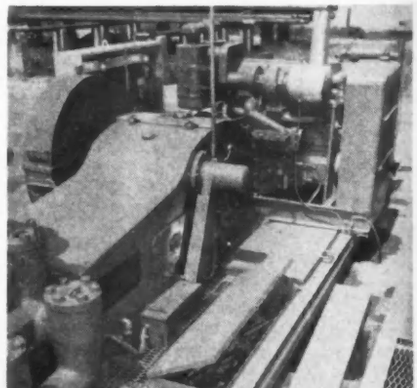
Guard Protects Man Guiding Sand Line

The sand line, in being run in deep holes, frequently is subjected to considerable punishment and, when coming out of the hole at high rates of speed, often tends to pile up and spool unevenly. It often is necessary to station a man beside or above the reel



to guide the line as it comes on to the spool.

One contractor, in providing a safe means and method of guiding the line, built a removable guard rail around the sand reel opening atop the drawworks housing. The guard, made of 1-inch pipe, is waist high and the legs rest in pipe sockets welded to the housing. The man, using a steel hook similar in size and shape to a hay hook, stands beside the guard and easily pulls the line to one side or the other as necessary to assure straight, even spooling, and with no chance of his accidentally slipping or being pulled into the spool area.



Store Tools and Fittings In Homemade Tool Box

Excellent use can be made of otherwise useless space within the skid base area of the mud pump platform. As shown in the photograph, large di-

mension, but shallow, steel boxes provide an ideal place to store those tools and fittings most likely to be used on the pump such as liner puller, packing, special wrenches, spare parts etc. The relatively shallow dimension of the boxes, in fact, facilitates accessibility of certain of the larger, heavier tools.

The covers overlap the projecting sides of the heavy-gage box, thus minimizing the chances of rain or mud splashing into the interiors. Diamond plate is used for the cover to provide non-skid surface for the safety of workmen servicing the pump. The covers are sufficiently heavy that they will support the weight of a man; also are unlikely to fly open when the pump is winched on or off a truck bed.

Have Neat Houskeeping With Improvised Rake

Keeping the grounds around a tank battery free of trash and looking neat and tidy can be a fairly easy task if the proper tools are provided. One indication of this type of ingenuity is shown in the accompanying photograph where the pumper welded three rakes together with a reinforcing bar across the heel of the rack by using a long, looping piece of sucker rod welded to each end to make an effective handle.

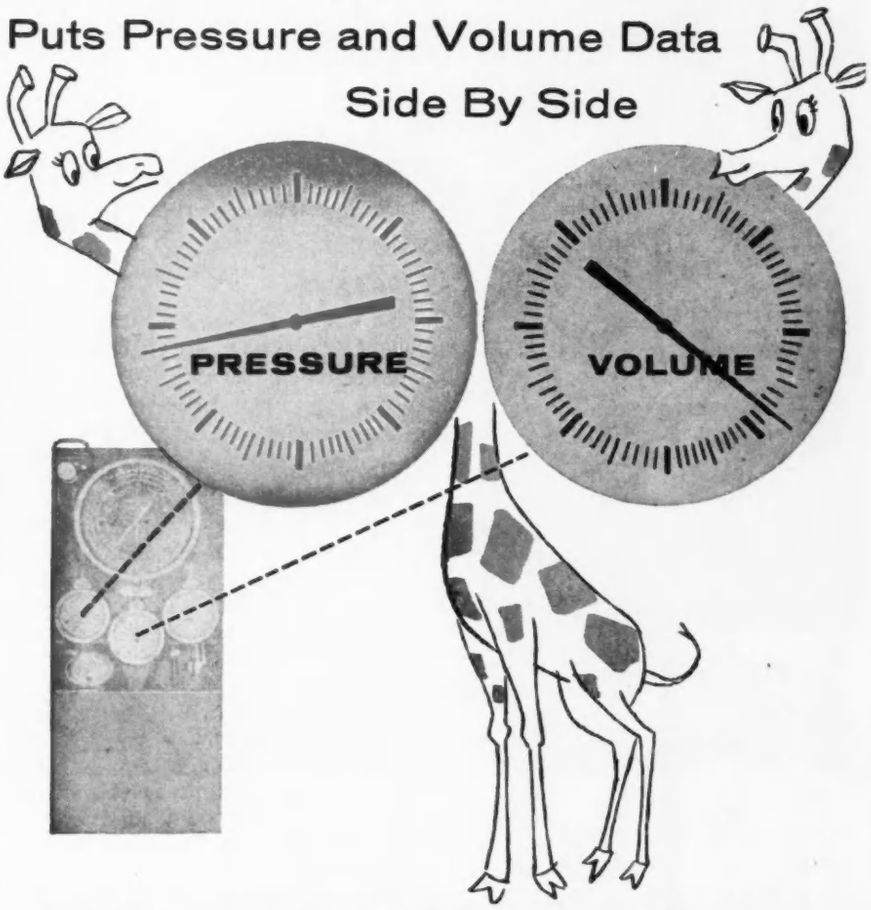
This enables an operator to rake the sand or gravel around a battery or well location in a lot less time provided it is merely a matter of housekeeping and not a question of reworking the dirt around the battery or making a new location. This would be an unhandy implement in the latter case.

Chain Fastened to Loading Ramp Holds Pipe in Place

A short piece of chain has been effectively used as a pipe stop to keep the pipe from sliding off the derrick floor.

The chain is fastened to each side of the loading ramp. The pipe is skidded over the chain so that the bottom end of the pipe lays against the chain. This keeps the pipe from sliding down the skid ramp.

It Takes Two – Only MARTIN-DECKER Puts Pressure and Volume Data Side By Side



MARTIN-DECKER Combination Pressure Gauges and Volume Indicators Tell the Complete Hydraulic Story

Two gauges are necessary, but two heads are not. Mud Pressure by itself does not tell the whole story. Both pressure and volume are needed. A pressure drop indicates trouble but is it a clue to a cut-out bit or tool joint, or is it a pump slowing down?

Hydraulics are becoming the most important single factor in drilling wells. The driller must know what his pumps are doing in order to: protect his equipment, follow his hydraulic program and quickly note any troubles so that prompt action can prevent serious damage. Only with both pressure and volume information can you know the complete story of your hydraulic system.

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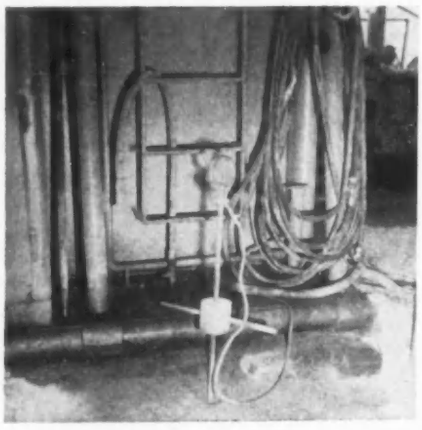
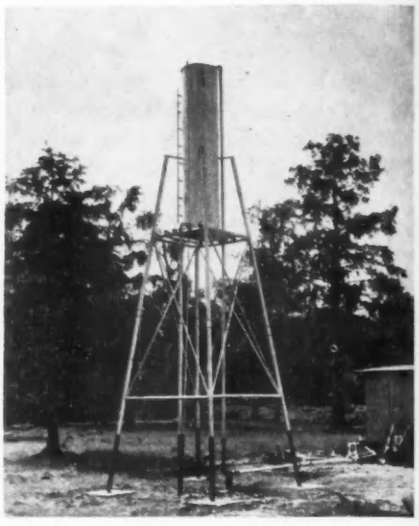


Use Built-In Hammer To Sink Ground Rod

Time and effort involved in rigging the light plant can be saved by equipping the ground rod with a built-in hammering device of the type illustrated. On the rod, and spaced about 18 inches apart, are welded two stops. The handle-equipped weight, working between the stops, is slammed down hard on the lower one a few times to sink the rod and, to remove it, is brought up hard against the upper stop.

The ground wire is attached to the rod between the top stop and the heavy ring handle. The unit is easily carried and stored inside the light plant house between rig moves.



Make Lease Water Tower With Scrap Pipe

This fresh water tower is constructed in the field with the aid of a welder. The unit is made completely of junk materials found around most leases. All principal supporting members (legs, cross-members, platform) are composed of 2½-inch line pipe or tubing. The angular bracing seen in the center portion of the leg section is composed of 1 or 1½-inch line pipe or tubing. The actual tank is constructed from 30-inch O.D. conductor pipe. The tank proper is made to any desired height and is sealed completely on each end.

Three connections are provided on the tank section. As indicated, the input and discharge lines are 2-inch line pipe. The input line is shown tied into a small steam pump which pumps water into the tank section. The ¾-inch line shown tied into the top of the tank is a gas line which can be used to pressure the tank section to as much as 100 psi in times of emergency (fire fighting purposes etc.). Normally the tank is operated by gravity.

Four concrete foundations were required to support the unit illustrated. This particular installation has been in use for some time and proved most satisfactory for all lease purposes.

WHY TOLERATE

— Rapid Wear Of Kelly & Kelly Bushings?

— Friction Hold Up Between Kelly & Kelly Bushings?

— Excessive Wear In Drive Squares?

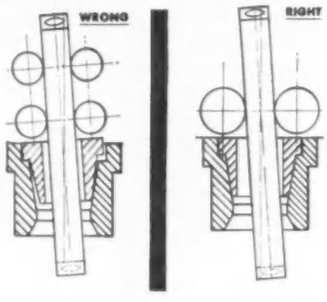
— Kelly Kinking?

VARCO

THE SELF COMPENSATING ROLLER KELLY BUSHINGS PROVIDE PERFECT INTERACTION BETWEEN THE SWIVEL AND THE ROLLERS OF THE BUSHING!

If the Crown Block is slightly off center—the Traveling Block swings due to wind or other adverse conditions—the Derrick leans or the Drill Pipe hugs the side of the hole, it is necessary to have a Drive Bushing which will compensate for such errors.

The superior design of VARCO ROLLER KELLY BUSHINGS provides perfect interaction for the Swivel and the Rollers of the Bushing. The Rollers, being located on one level, act not only as a driving mechanism, but also as a guide to the Kelly Stem, and in no way interfere with the constantly moving swivel due to unfavorable working conditions or location. The Swivel, being in reality a universal joint, is unencumbered in its motion. This eliminates friction and prevents bind on the Kelly. The Kelly stem follows the Drill Stem freely and as the bushing revolves smoothly, and noiselessly in the table the Kelly is not restricted.



You'll like these additional advantages of

VARCO ROLLER KELLY BUSHINGS

• One Varco Roller Bushing Body is adaptable to all types and sizes of Kellys • Rollers mounted on Roller Bearings fully envelop the Kelly • VARCO Roller Kelly Bushings, with exposed Rollers, can be completely washed of mud • VARCO Roller Kelly Bushings always remain in the table when reaming, drilling up, or jarring.

SEE OUR SECTION IN THE COMPOSITE CATALOG OR WRITE FOR NEW CATALOG

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CONTINENTAL RED SEALS *"Stand Up and Take It"* ON THE TOUGHEST OIL FIELD JOBS

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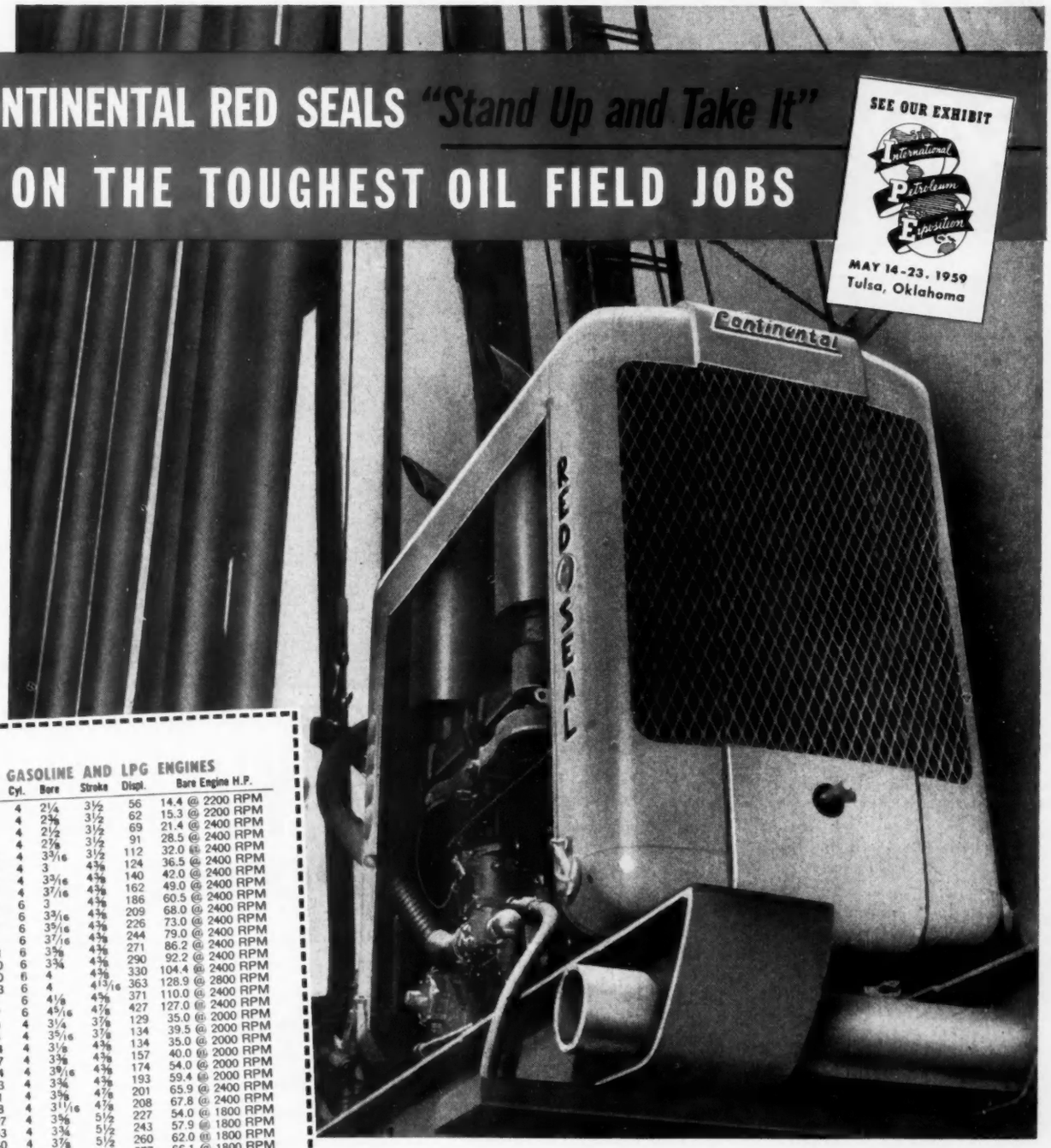

GASOLINE AND LPG ENGINES

Model	Cyl.	Bore	Stroke	Displ.	Bare Engine H.P.
N56	4	2 1/4	3 1/2	56	14.4 @ 2200 RPM
N62	4	2 3/8	3 1/2	62	15.3 @ 2200 RPM
Y69	4	2 1/2	3 1/2	69	21.4 @ 2400 RPM
Y91	4	2 7/8	3 1/2	91	28.5 @ 2400 RPM
Y112	4	3 3/16	3 1/2	112	32.0 @ 2400 RPM
F124	4	3	4 3/8	124	36.5 @ 2400 RPM
F140	4	3 3/16	4 3/8	140	42.0 @ 2400 RPM
F162	4	3 7/16	4 3/8	162	49.0 @ 2400 RPM
F186	6	3	4 3/8	186	60.5 @ 2400 RPM
F209	6	3 3/16	4 3/8	209	68.0 @ 2400 RPM
F226	6	3 5/16	4 3/8	226	73.0 @ 2400 RPM
F244	6	3 7/16	4 3/8	244	79.0 @ 2400 RPM
M271	6	3 5/8	4 3/8	271	86.2 @ 2400 RPM
M290	6	3 3/4	4 3/8	290	92.2 @ 2400 RPM
M330	6	4	4 3/8	330	104.4 @ 2400 RPM
M363	6	4	4 13/16	363	128.9 @ 2800 RPM
B371	6	4 1/8	4 5/8	371	110.0 @ 2400 RPM
B427	6	4 5/16	4 7/8	427	127.0 @ 2400 RPM
*Z129	4	3 1/4	3 7/8	129	35.0 @ 2000 RPM
*Z134	4	3 5/16	3 7/8	134	39.5 @ 2000 RPM
G134	4	3 1/8	4 3/8	134	35.0 @ 2000 RPM
G157	4	3 3/8	4 3/8	157	40.0 @ 2000 RPM
*G174	4	3 9/16	4 3/8	174	54.0 @ 2000 RPM
*G193	4	3 3/4	4 3/8	193	59.4 @ 2000 RPM
*E201	4	3 5/8	4 7/8	201	65.9 @ 2400 RPM
*E208	4	3 11/16	4 7/8	208	67.8 @ 2400 RPM
H227	4	3 5/8	5 1/2	227	54.0 @ 1800 RPM
H243	4	3 3/4	5 1/2	243	57.9 @ 1800 RPM
*H260	4	3 7/8	5 1/2	260	62.0 @ 1800 RPM
*H277	4	4	5 1/2	277	66.1 @ 1800 RPM
K363	6	4	4 13/16	363	123.0 @ 2400 RPM
*J382	4	4 1/2	6	382	74.0 @ 1400 RPM
*U403	4	4 5/8	6	403	110.0 @ 2000 RPM
T371	6	4 1/8	4 5/8	371	119.0 @ 2400 RPM
T427	6	4 5/16	4 7/8	427	140.0 @ 2400 RPM
U501	6	4 1/2	5 1/4	501	160.0 @ 2400 RPM
R513	6	4 1/2	5 3/8	513	164.3 @ 2400 RPM
R572	6	4 3/4	5 3/8	572	182.4 @ 2400 RPM
R602	6	4 7/8	5 3/8	602	191.7 @ 2400 RPM
V603	8	4 3/4	4 1/4	603	240.0 @ 2800 RPM
S749	6	5 3/8	5 1/2	749	217.0 @ 2200 RPM
S820	6	5 5/8	5 1/2	820	237.0 @ 2200 RPM

CUSHIONED POWER DIESEL ENGINES

Model	Cyl.	Bore	Stroke	Displ.	Bare Engine H.P.
*ZD129	4	3 1/4	3 7/8	129	34.0 @ 2000 RPM
GD157	4	3 3/8	4 3/8	157	39.0 @ 2000 RPM
*GD174	4	3 9/16	4 3/8	174	42.5 @ 2000 RPM
*GD193	4	3 3/4	4 3/8	193	55.5 @ 2200 RPM
*ED201	4	3 5/8	4 7/8	201	45.8 @ 2000 RPM
*ED208	4	3 11/16	4 7/8	208	61.5 @ 2200 RPM
HD243	4	3 3/4	5 1/2	243	68.9 @ 2200 RPM
*HD260	4	3 7/8	5 1/2	260	74.0 @ 2400 RPM
*HD277	4	4	5 1/2	277	79.0 @ 2400 RPM
*JD382	4	4 1/2	6	382	87.4 @ 2000 RPM
*UD403	4	4 5/8	6	403	91.5 @ 2000 RPM
TD427	6	4 5/16	4 7/8	427	132.0 @ 2200 RPM
RD572	6	4 3/4	5 3/8	572	154.0 @ 2000 RPM
VD603	8	4 3/4	4 1/4	603	197.0 @ 2600 RPM
SD802	6	5 9/16	5 1/2	802	202.0 @ 1800 RPM

*Available for industrial applications only.

No matter what the exact requirement of the job, there's a Continental Red Seal model engineered and built to meet it down to the last detail. The industrial engine power range is a broad one, with models at closely-spaced levels—14 to 240 horsepower—and they're available for operation on all standard fuels. Each is the product of more than 56 years' engine-building experience—each with the in-built stamina to "stand up and take it" on the toughest oil field jobs year after year—and each backed by parts and service facilities that reach around the world.

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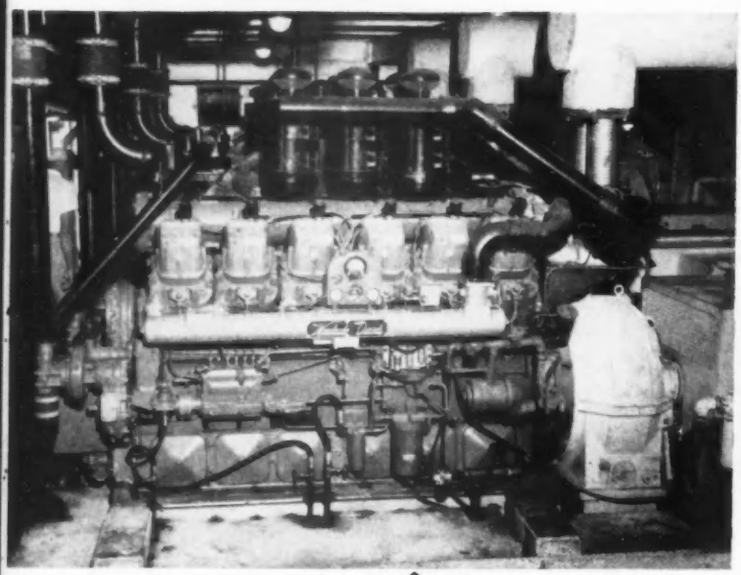
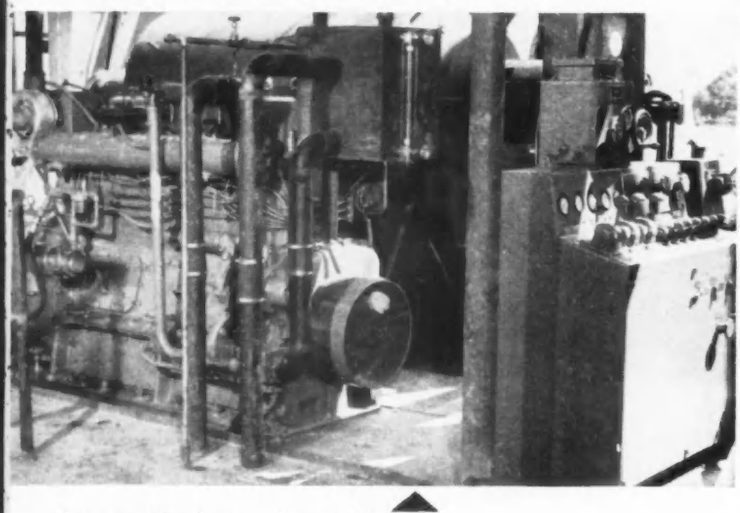
NEW Two-R Drilling Co. BARGE No. 1



(drilling engines—drawworks and mud pumps)
Three Waukesha VLRDBSU Turbocharged 12-cyl. Diesels



(rotary table drive and catworks)
Waukesha NKDBSU Turbocharged Diesel

all-WAUKESHA POWERED

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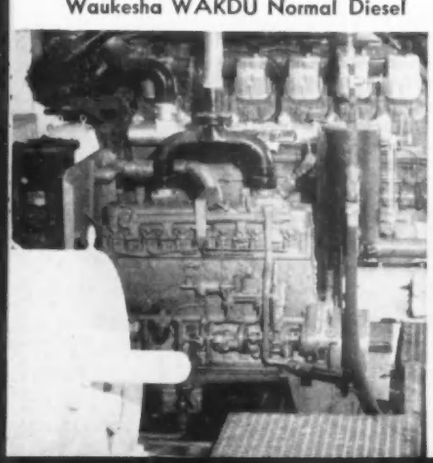
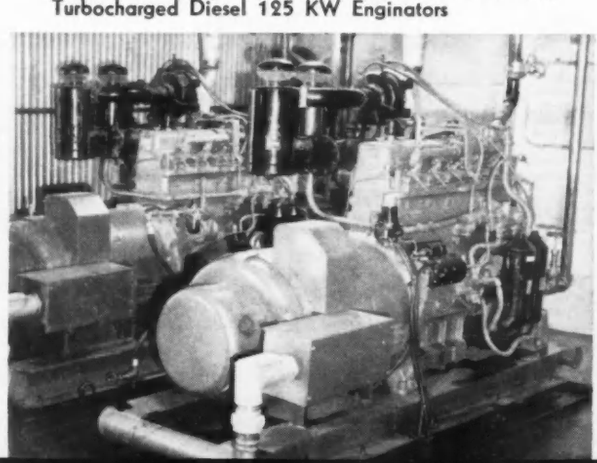
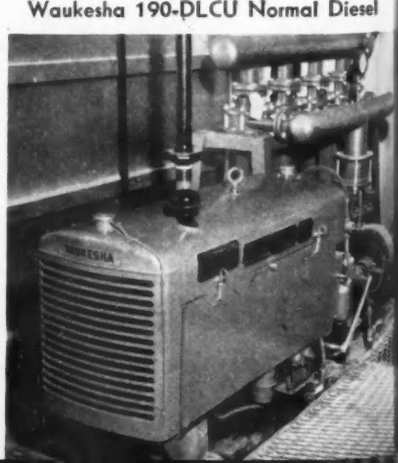
(mud mix pump)
Waukesha WAKDU Normal Diesel



(main electrical power) Two Waukesha WAKDBSU Turbocharged Diesel 125 KW Enginators



(de-sander unit)
Waukesha 190-DLCU Normal Diesel



Tangential Water Pipe Makes Better Blow Barrel

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The illustrated blow barrel is not unique, but the method of adding the wash water is. As seen in the picture, water enters the blow barrel tangentially through two pipes. This creates a rolling of the water and clothes in the barrel, giving additional cleansing power.

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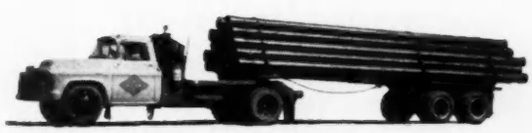
Lone Star API casing, tubing and line pipe represent steel pipe at its best. Exacting multiple tests assure the toughness . . the stamina . . the long service that the oil and gas industry demands. Joe Roughneck knows that Lone Star has every step of pipemaking under control . . quality control . . from mining of ore to finished pipe.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.



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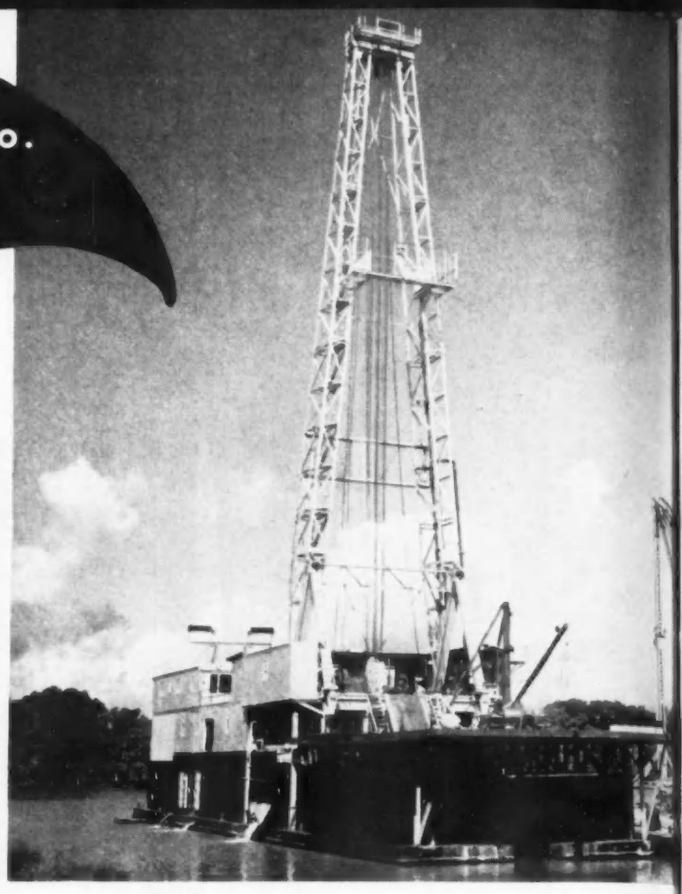

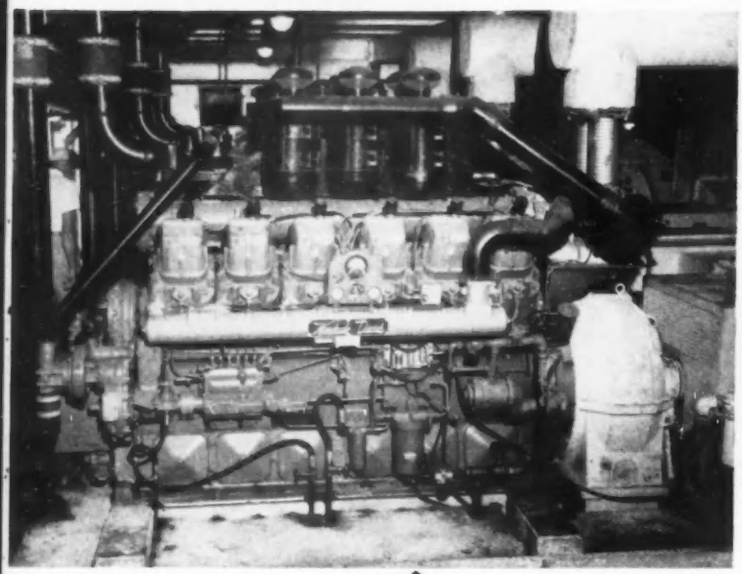

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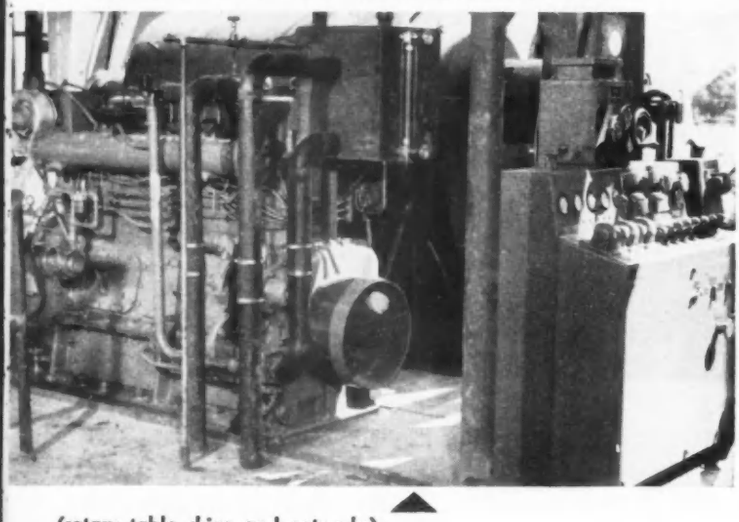

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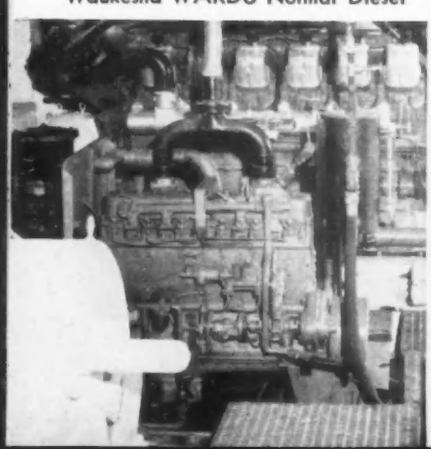

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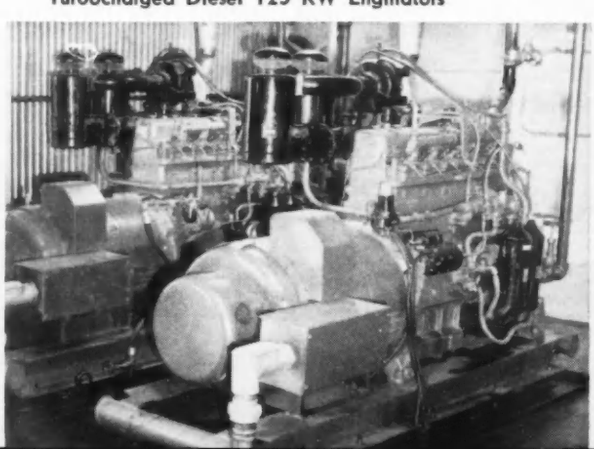

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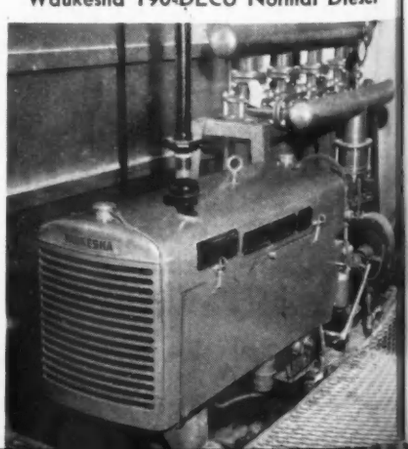

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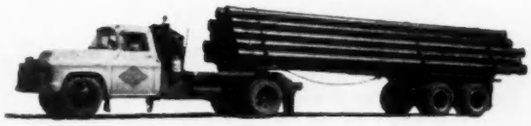

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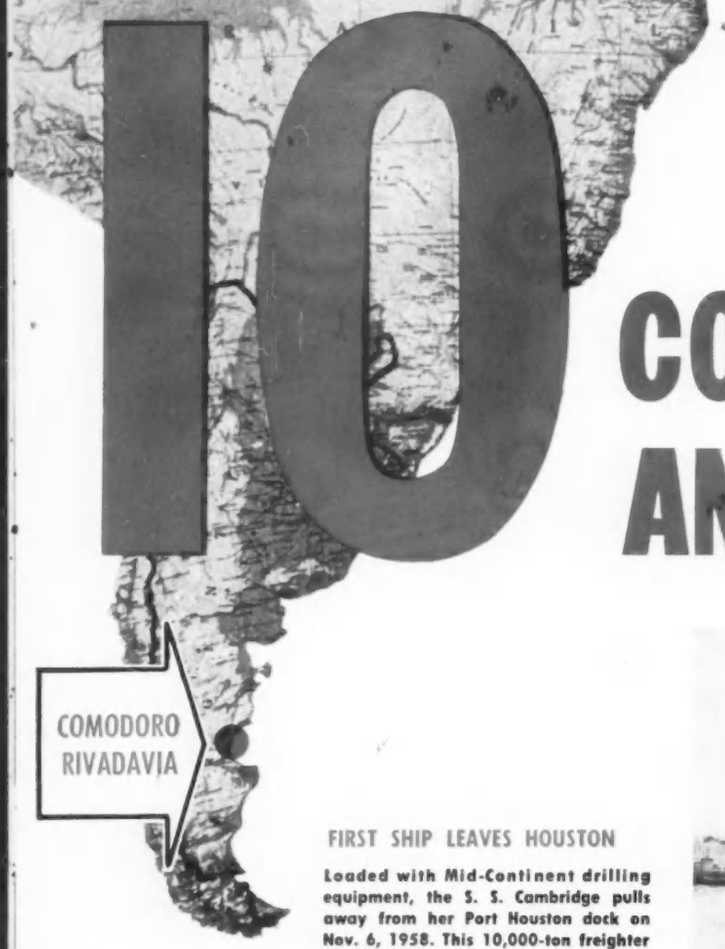
Each trailer-mounted rig, capable of drilling 9,500 feet, is equipped with Mid-Continent's U-36-A drawworks, rig drives, rotary tables and blocks, Cummins diesel engines, Emsco pumps and a 126-foot Lee C. Moore telescoping mast. Rigs, specially-designed for Argentine drilling, are fully-portable.

10 COMPLETE RIGS AND SHIPPED TO



FIRST SHIP LEAVES HOUSTON

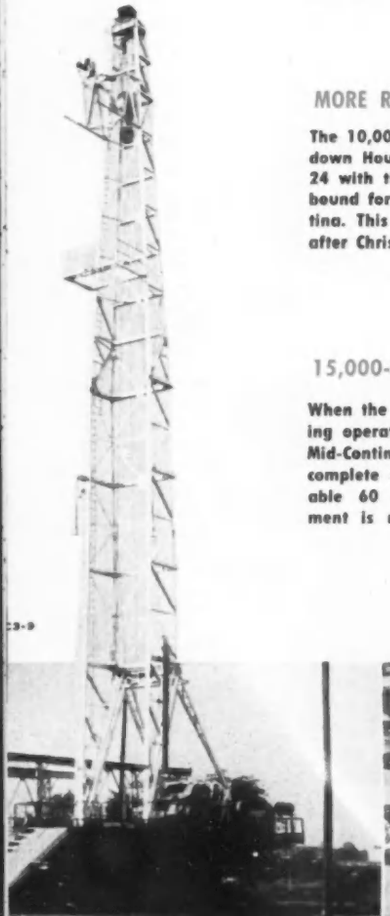
Loaded with Mid-Continent drilling equipment, the S. S. Cambridge pulls away from her Port Houston dock on Nov. 6, 1958. This 10,000-ton freighter arrived in Argentina on Dec. 4 with the first three rigs.

MORE RIGS FOR ARGENTINA

The 10,000-ton S. S. Elderfields steams down Houston's Ship Channel on Nov. 24 with three more Mid-Continent rigs bound for Comodoro Rivadavia, Argentina. This shipment was delivered just after Christmas.

15,000-TON FREIGHTER LOADS UP

When the S. S. Dorian completed loading operations in Houston on Dec. 15, Mid-Continent Supply had shipped ten complete drilling rigs in an unbelievable 60 days! Most of this equipment is now in operation.



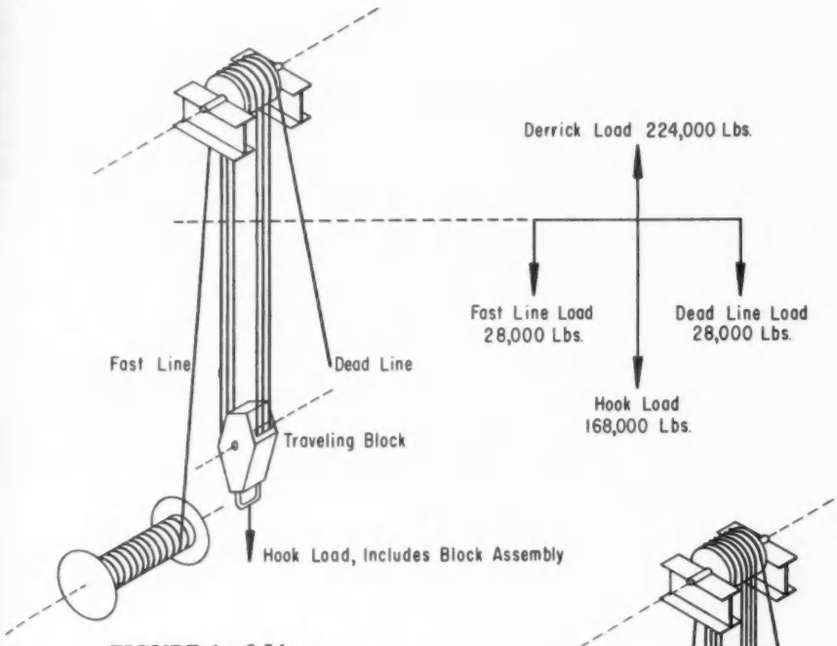


FIGURE 1—6 Lines

These drawings show a loading diagram of a 6-line system vs. an 8-line system. They also illustrate the various component parts of a drilling rig hoisting assembly.

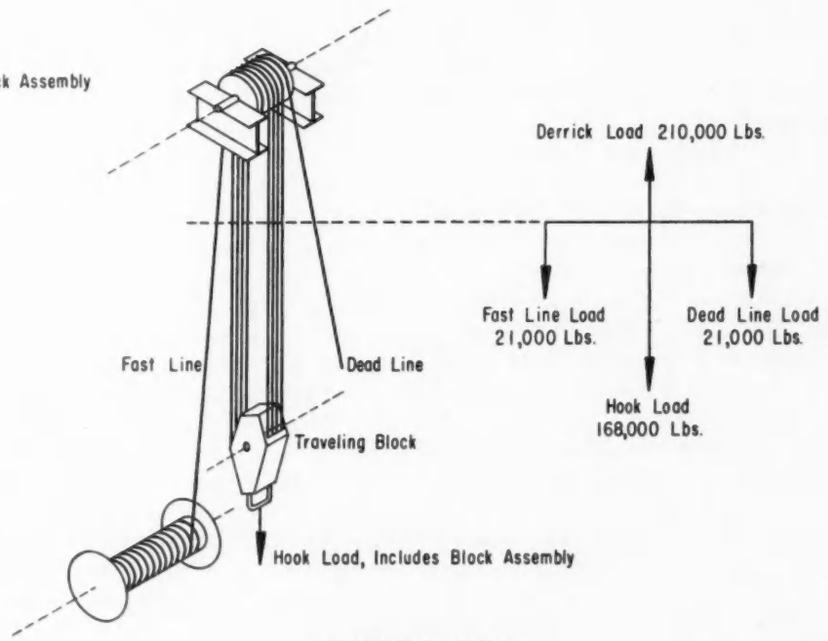


FIGURE 2—8 lines

6 or 8 lines . . .

Which hoisting system is better?

Eight lines are more desirable to reave the derrick when derrick loading, shock, impact, acceleration and safety are immediate objectives

By Billy G. Williams, Mechanical Engineer
Panhandle Drilling Company, Amarillo, Texas

CAN THE WEIGHT on the derrick be reduced by adding more lines in the derrick of a drilling rig? In other words, will the derrick load be reduced immediately after changing from 6 to 8 lines?

When discussing this controversial question, many drillers say that adding more lines makes it easier for the motors to pull the load because additional lines reduce the pull on each line. But drillers often maintain that the derrick has a certain amount of weight to hold up and that this weight cannot be reduced.

This article will show how to prove that adding more lines to the derrick actually will reduce the load on the

derrick, and also will present other information that will enable drillers to operate rigs with greater safety.

Derrick load. Consider first a free body diagram showing all forces acting on the derrick, (Figures 1 and 2). When the derrick is operating with 6 lines to the traveling block, the derrick holds up the pull of these 6 lines, plus the pull of the fast line, plus the pull of the dead line. The fast line would include the accumulation of friction on all sheaves. Not considering friction and the weight of the lines, and assuming that the hook load is 168,000 pounds, the pull on each line is 168,000 divided by 6 or 28,000 pounds. The weight on the derrick would be 8 times 28,000 or 224,000 pounds.

Now consider the derrick with 8 lines, and the same 168,000 pounds of hook load. Each line would be carrying 168,000 divided by 8 or 21,000 pounds and the total weight on the derrick would be 10 times 21,000 or 210,000 pounds. This shows the reduction of 14,000 pounds by changing from 6 to 8 lines on the traveling block.

By referring to a toolpusher's manual, under the strength and loading of wire lines, this information can be obtained. When a 1⅛-inch diameter 6 x 19 Seal improved Plow Steel IWRC line with a breaking strength of 56.5 tons is used in stringing the traveling block with a hook load of 168,000 pounds, the dead line load is 28,000 pounds, the fast line load is 32,000 pounds and the weight on the derrick is 228,000 pounds. This is considering friction on all sheaves with six lines being used to string the traveling block.

When 8 lines are used instead of 6 to string the traveling block, and for the same hook load of 168,000 pounds the dead line load would be 21,000 pounds, the fast line load would be 25,000 pounds and the derrick load would be 214,000 pounds. This also shows a reduction of 14,000 pounds when changing from 6 to 8 lines. Thus, the fact has been established that by adding more lines to the traveling block, the load on the derrick is reduced.

Factor of safety. The life of a wire rope is dependent upon the safety factor. Therefore, longer rope life generally can be expected when relative high factors of safety are maintained.

The factor of safety should be determined by the following formula:

$$\text{Factor of Safety} = \frac{B}{W}$$

Wherein:

B is equal to the nominal breaking strength of wire rope in pounds.

W is equal to the calculated static load in pounds.

For the previously discussed load of 168,000 pounds, and when 6 lines were used, the fast line had a load of 32,000 pounds. The breaking strength of the line used was 56.5 tons or 113,000 pounds. The factor of safety would be 113,000 divided by 32,000 or 3.5.

When 8 lines were used, the factor of safety would be 113,000 divided by 25,000 or 4.5.

The American Petroleum Institute recommends that the minimum factor of safety for wire lines used in rotary drilling is 3 and that when a wire rope is operated close to its minimum factor of safety, care should be taken that the rope and related equipment are in good operating condition. This means that operators should at all times use diligent care to minimize shock, impact, and acceleration or deceleration of loads, and should be especially careful when they are operating near the minimum factor of safety.

Shock, impact, and acceleration. Adding more lines in the derrick decreases shock and impact on the lines and on the derrick. This is one of the most important reasons for adding more lines. If, when the line drum begins to rotate, there is any slack line to be taken up before the load is moved, there will be considerable impact load on the line. This impact may be determined by the usual impact equations if acceleration of the line is known so the velocity at the instant of impact can be determined. It is necessary to estimate this impact load since computation is impossible due to unknown, variable factors for each rig and each time the load is picked up.

While making a round trip, operators usually run their rigs as fast as possible to get back on bottom to start drilling again. With the addition of more lines, the driller will tend to increase the speed of the fast line. Experience has indicated that excessive speeds may injure wire rope when the blocks are running up light. A maximum rope speed of 4,000 feet of rope travel per minute for hoisting or lowering is recommended.

When the blocks are loaded, economy results from moderately increasing the load and diminishing the speed. This will prevent shock loading on the wire lines. Shock loading imposes a severe strain on the line, causing it, in some cases, to neck down. Strands then will become unbalanced which will cause early retirement.

Sheave diameter. Because of the bending stresses developed when wire line wraps around the sheaves, it is important that sheave diameters be kept fairly large. This is especially true with high speed wire lines in continuous service, when the fatigue action will materially affect the life of the line.

Since using more lines will reduce the stress on each line, a smaller diameter sheave could be used with 8 lines than could be used with 6 lines. However, it is not the practice to change the sheaves on a derrick, and the sheaves used should have a large enough diameter to take care of the minimum number of lines used. The smaller stress developed when adding more lines will prolong the life of the wire lines.

Load of motors. The load on the prime mover is substantially reduced for a particular hook load when more lines are used. It is apparent that for a given hook load less horsepower would be repuired to handle the load if 8 lines were used than if 6 lines were used.

Weight indicator. If more lines are added, the weight ratio between the dead line and the hook load will be changed. Thus, the weight indicator must be reset to show the correct weight being picked up by the traveling block. This sometimes is confusing to drillers because after changing from 6 to 8 lines and resetting the weight indicator, they still have the same load. It should be recognized that the weight indicator only shows the load being picked up by the traveling block

Continued on Page 89

Material balance equations for gas reservoirs with water drive

Minimum of data is required to use recently developed combination of a simple material balance and water influx equation

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EARLY IN THE life of any hydrocarbon reservoir, establishment of the magnitude of the reserves and the relative efficiency of any natural water drive which may be encountered is desirable. Knowledge of these factors assists appreciably in efficient and economic development and operation of a reservoir. Drilling of superfluous wells can be avoided, and the necessary wells can be utilized more profitably and advantageously.

A reasonable estimate of original reesrves in a reservoir and the degree of water drive may be determined by the application of a material balance equation in conjunction with a water influx equation. These basic concepts and their application to actual reservoirs have been discussed by numerous investigators.[1, 2, 3, 4, 5] However, these articles, and more particularly the cited examples, refer rather specifically to oil reservoirs, although the fundamental principles apply to gas and gas-condensate reservoirs with equal significance and ultimate benefit.

With these considerations in mind, a simple material balance equation for gas reservoirs has been combined with the Schilthuis water influx equation. The resultant material balance equation is as follows:

$$C\int_0^t \Delta P dt - w_t = V_o\left(1-\frac{P_o Z_t}{P_t Z_o}\right)+\frac{.0282 T_r Z_t Q_t}{P_t}$$

To demonstrate the use of this equation, the original hydrocarbon pore volume, the initial gas in place and the progressive water influx were calculated for an actual gas condensate reservoir in West Texas. The material balance calculations shown in Tables 1 and 2 indicate that the original hydrocarbon pore space in this reservoir was 1.225×10^9 cubic feet. Based on this original hydrocarbon pore space and the known reservoir temperature and pressure, original gas in place is calculated to be 342 billion standard cubic feet. The measured full stream gas/

TABLE 1

$$^{*}C\int_0^t \Delta P dt = V_o\left(1-5252\frac{Z_t}{P_t}\right)+18.894\left(\frac{Z_t}{P_t}\right)q_t + W_t$$

DATE	(1) Pressure P.	(2) ΔP	(3) $\frac{}{\Delta P}$	(4) dt, mos.	(5) $\frac{}{\Delta Pdt}$	(6) $\int_0^t \Delta P dt$	(7) $\frac{Z_t}{P_t}$	(8) $1-5252\frac{Z_t}{P_t}$	(9) Cum. Gas Prod. MCF	(10) Cum. Condensate BBLS.	(11) Equivalent MCF @ 800 SCF/B	(12) q_t, MCF	(13) $18.894\,q_t\frac{Z_t}{P_t}$	(14) W_t BBLS.	(15) $W_t \times 5.615$ ft.³	(16) (13) + (15)
		515	(Fr. Orig.)		6,425											
Apr. 1951	4,370	635	575	6	3,450	9,875	2.0069 x 10—4	—0.0540	19,406,546	3,404,246	2,723,397	22,129,943	83,913,136	707,667	3,973,550	87,886,686
Oct. 1951	4,283	722	678.5	6	4,071	13,946	2.0266 x 10—4	—0.0644	24,104,888	4,225,142	3,380,114	27,485,002	105,241,665	923,790	5,187,081	110,428,746
Apr. 1952	4,213	792	757	6	4,542	18,488	2.0389 x 10—4	—0.0708	28,399,089	4,984,643	3,987,714	32,386,803	124,763,618	1,085,020	6,092,387	130,856,005
Oct.	4,175	830	811	6	4,866	23,354	2.0503 x 10—4	—0.0768	32,060,628	5,653,130	4,522,504	36,583,132	141,717,090	1,226,116	6,884,641	148,601,731
Apr. 1953	4,146	859	844.5	6	5,067	28,421	2.0550 x 10—4	—0.0793	35,028,668	6,207,489	4,965,991	39,994,659	155,287,943	1,365,631	7,668,018	162,955,961
Oct.	4,118	887	873	6	5,238	33,659	2.0617 x 10—4	—0.0828	38,116,339	6,815,835	5,452,668	43,569,007	169,717,664	1,486,032	8,344,070	178,061,734
Apr. 1954	4,100	905	896	6	5,376	39,035	2.0658 x 10—4	—0.0850	41,257,174	7,375,735	5,900,588	47,157,762	184,062,545	1,638,279	9,198,937	193,261,482
Oct.	4,084	921	913	6	5,478	44,513	2.0690 x 10—4	—0.0866	44,325,218	7,916,266	6,333,013	50,658,231	198,031,585	1,785,113	10,023,409	208,054,994
Apr. 1955	4,071	934	927.5	6	5,565	50,078	2.0707 x 10—4	—0.0875	47,374,693	8,430,036	6,744,029	54,118,722	211,733,059	1,935,435	10,867,468	222,600,527
Oct.	4,061	944	939	6	5,634	55,712	2.0709 x 10—4	—0.0876	50,198,068	8,935,061	7,148,049	57,346,117	224,381,477	2,144,904	12,043,636	236,425,113
Apr. 1956	4,056	949	946.5	6	5,679	61,391	2.0710 x 10—4	—0.0877	53,095,266	9,423,576	7,538,861	60,634,127	237,258,125	2,372,787	13,323,199	250,581,324
Oct.	4,051	954	951.5	6	5,709	67,100	2.0735 x 10—4	—0.0891	55,539,913	9,846,437	7,877,150	63,417,063	248,447,187	2,552,839	14,334,191	262,781,378

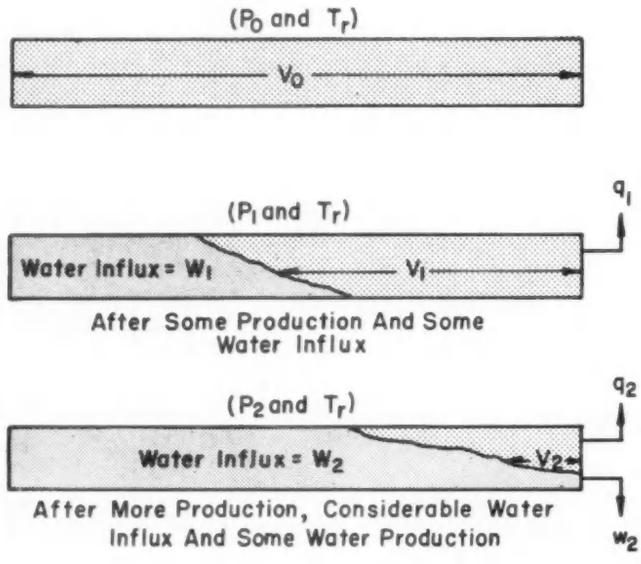
* The equation has been rewritten, substituting 670°R for T_r and 5252 psia for P_o/Z_o, and transferring the cumulative produced water term, w, to the right hand side.

stock tank condensate ratio is 6445 scf/bbl., which indicates an original stock tank liquid reserve in place of 53 million barrels. (In this instance, it should be mentioned that the water influx appears sufficient, relative to the producing rate, to maintain the reservoir pressure above the dew point, eliminating the complication of retrograde liquid condensation in the reservoir.)

Core data from one well. Although this is a large reservoir with numerous wells, complete core data are available from only one well. The reservoir rock is fractured dolomite, with characteristic inhomogeneity. With available data, only a crude estimate of the hydrocarbon pore volume could be made by the usual volumetric methods. Nevertheless, there is acceptable agreement between the reservoir pore volume as determined by the volumetric method and this material balance equation.

In considering this method of evaluating original reserves and subsequent water encroachment into gas reservoirs, it is particularly noteworthy that an absolute minimum of data is required, namely pressure and production history. These data normally are available in gas reservoirs of any appreciable size, permitting ready application of this method of estimating the performance of gas and gas-condensate reservoirs.

DERIVATIONS OF EQUATIONS— INITIAL CONDITIONS



The above sketches represent the total hydrocarbon pore space in the reservoir, and the symbols have the following meanings:

V_o = Initial hydrocarbon pore space, cf.

V_1 = Hydrocarbon pore space remaining at P_1 (before any water production)

V_2 = Hydrocarbon pore space remaining at P_2 (after some water production)

P_o = Original reservoir pressure, psia

$P_1, P_2, \cdots P_n$ = Successive reservoir pressures @ times $t_1, t_2, \cdots t_n$

T_r = Reservoir temperature, °R

Z_o = Compressibility @ P_o and T_r, equals PV/RT

$Z_1, Z_2, \cdots Z_n$ = Compressibility @ T_r and $P_1, P_2, \cdots$ and P_n

q_1 = Cumulative full stream gas production before water break-through, Std. Cubic Feet

q_2 = Cumulative full stream gas production, after water break-through, Std. Cubic Feet

Q_o = Volume of gas originally in reservoir, Std. Cubic Feet

W = Cumulative water influx into gas reservoir, Cubic Feet

w = Cumulative water produced, Cubic Feet

DEVELOPMENT

The compressibility of the reservoir rock and reservoir water have been considered insignificant relative to gas.

$$1.\ Q_o = \frac{520}{14.65}\ \frac{P_o V_o}{T_r Z_o} = 35.5\,\frac{P_o V_o}{T_r Z_o}\ \text{scf}$$

$$2.\ V_1 = \frac{T_r Z_1 (Q_o - q_1)\,14.65}{520 P_1} = .0282\ \frac{T_r Z_1 (Q_o - q_1)}{P_1}\ \text{cf}$$

Prior to any water production:

$$3.\ W_1 = (V_o - V_1)\ \text{cubic feet}$$

From 1. and 2.:

$$4.\ V_1 = .0282\,\frac{T_r Z_1}{P_1}\left(35.5\,\frac{P_o V_o}{T_r Z_o} - q_1\right)\ \text{cubic feet}$$

Combining 3. and 4.:

$$5.\ W_1 = V_o\left(1 - \frac{Z_1 P_o}{P_1 Z_o}\right) + \frac{.0282 T_r Z_1 q_1}{P_1}$$

After beginning of water production:

$$6.\ W_2 - w_2 = V_o\left(1 - \frac{Z_2 P_o}{P_2 Z_o}\right) + \frac{.0282 T_r Z_2 q_2}{P_2}$$

Generalizing for taking the balance at any time:

$$7.\ W_t - w_t = V_o\left(1 - \frac{Z_t P_o}{P_t Z_o}\right) + \frac{.0282 T_r Z_t q_t}{P_t}$$

Schilthuis gives a simple relation for water influx which

TABLE 2—Simultaneous Solution of Equations for Determination of V_o and C.

$$\left(\int_o^t \triangle P dt\right) C = \left(1 - 5252\,\frac{Z_t}{P_t}\right) V_o + \left(18.894\left(\frac{Z_t}{P_t}\right) + W_t\right)$$

				Calculated
	9,875 C	= —0.0540 V_o +	87,886,686	V_o = 1,206,106,444
	13,946 C	= —0.0644 V_o +	110,428,746	V_o = 1,215,686,164
	18,488 C	= —0.0708 V_o +	130,856,005	V_o = 1,246,474,703
	23,354 C	= —0.0768 V_o +	148,601,731	V_o = 1,234,146,328
	28,421 C	= —0.0793 V_o +	162,955,961	V_o = 1,229,000,832
	33,659 C	= —0.0828 V_o +	178,061,734	V_o = 1,213,702,510
(1)	127,734 C	= —0.4281 V_o +	818,790,863	V_o = 1,224,964,071
	39,035 C	= —0.0850 V_o +	193,261,482	V_o = 1,227,121,470
	44,513 C	= —0.0866 V_o +	208,054,994	V_o = 1,217,953,640
	50,078 C	= —0.0875 V_o +	222,600,527	V_o = 1,225,094,580
	55,712 C	= —0.0876 V_o +	236,425,113	V_o = 1,233,296,900
	61,391 C	= —0.0877 V_o +	250,581,324	V_o = 1,244,079,400
	67,100 C	= —0.0891 V_o +	262,781,378	V_o = 1,213,798,290
(2)	317,829 C	= —0.5235 V_o +	1,373,704,818	V_o = 1,224,962,536

(1) x 0.5235: 66,873 C = —0.2241 V_o + 428,637,017
(2) x 0.4281: 136,063 C = —0.2241 V_o + 588,083,033
69,190 C = 159,446,016
C = 2304.5 Ft.³/mo./psi
154,108,829 = —0.2241 V_o + 428,637,017
V_o = 1,225,025,381 Ft.³ of hydrocarbon pore space

This method requires an absolute minimum of data . . .

takes into account its variation with time and the pressure differential between the aquifer and the field proper. The equation is stated as follows:

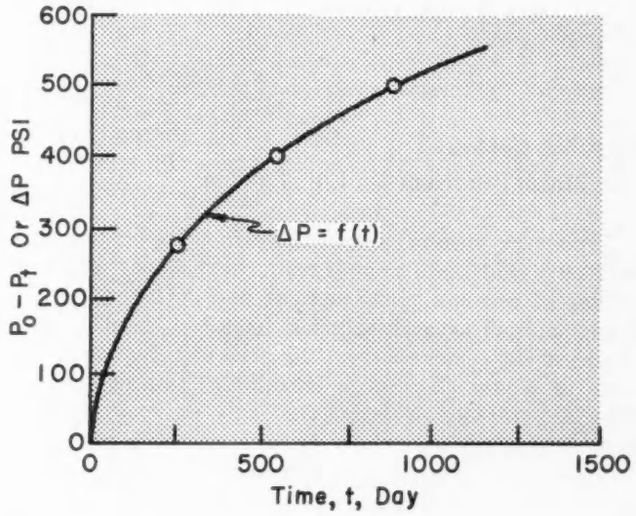
$$W_t \sim \int_o^t \Delta P dt, \text{ or}$$

$$8.\ W_t = C \int_o^t \Delta P dt$$

where: ΔP = Cumulative pressure drop at any time from the original reservoir pressure, P_o, to some later pressure, P_t, or $(P_o - P_t)$

C = A constant which has the dimensions—volume units/time unit/psi

Equation 8 may be clarified by noting the graphic representation below:



The equation of the curve is $\Delta P = f(t)$, and the area under the curve between some time t, and $t = o$ equals:

$$\int_o^t \Delta P dt, \text{ which may be}$$

approximated by

$$\sum_o^t \Delta P \times \Delta t$$

Combining Equation 8 with Equation 7 gives the complete water drive balance equation:

$$9.\ C \int_o^t \Delta P dt - w_t = V_o \left(1 - \frac{Z_t P_o}{P_t Z_o}\right) + \frac{.0282 T_r Z_t q_t}{P_t}$$

About the Authors

Fraser

Jack R. Fraser was graduated from the University of Pittsburgh in June, 1941. He was employed as a junior engineer by the Equitable Gas Company from June, 1941, until April, 1942, when he enlisted in the U. S. Army. After discharge, he was employed by Shell Oil Company as an exploitation engineer in January, 1946. After working in Kansas, Oklahoma and North and South Texas, Fraser was employed by Texas Eastern Production Corporation in October, 1951, as district geologist. He was named chief petroleum engineer for Texas Eastern in 1953, and held that position until February, 1956, when he became associated with Republic Natural Gas in the Dallas office. He now is senior staff engineer with Republic performing routine and specialized reservoir and economic studies and is responsible for Republic's gas sales contracts.

Campbell

Arnold E. Campbell is senior staff engineer in the Economics and Evaluation department of British-American Oil Producing Company, Dallas. He was graduated from Oklahoma in 1950 and went to Shell upon graduation. He has a B.S. in petroleum engineering. With Shell, Campbell worked as an exploitation engineer in Canada until December, 1952, when he went to Republic. With Republic, Campbell was district engineer at Pauls Valley, Okla., and a staff engineer in the Dallas office. He has been with British-American since November, 1957.

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Analyzing mud solids saves time and money

Knowing the total mud solids is a necessity in maintaining proper viscosity characteristics

By P. W. Cooke
The British Petroleum Co. Ltd., London

VISCOSITY TROUBLES, especially in weighted muds, result either from the action of contaminants, such as cement, anhydrite and salt, or from chemical deficiency or from the presence of excess clay solids entrained into the mud stream during the drilling process.

The drilled clay solids concentration in the mud, especially when penetrating mud-making formations, is the main factor influencing viscosity. The purpose of the more common treating chemicals is to enable the mud to tolerate more drilled solids without losing desired qualities of viscosity and fluid loss. Chemical effectiveness goes only so far and then it becomes expedient to reduce the clay solids concentration to avoid excessive viscosity rises. This may be accomplished either by watering-back and reweighing or, preferably, by the application of centrifuges and cyclones which discard the undesirable clay solids from a weighted mud without removing the weight material.

Increases in viscosity and gels resulting from (a) contamination or chemical deficiency or (b) excess clay solids content may be distinguished by carrying out routine determinations of the total solids content of the mud. A viscosity increase unaccompanied by a rise in solids content is indicative of chemical deficiency or contamination and usually may be remedied by the addition of further chemicals.

The total solids content usually is determined by heating a known volume of mud in a steel container, passing the vaporized liquid components through a condenser and collecting them in a graduated cylinder. The difference between the initial mud volume taken and the total volume of fluid components (oil and water) is the total solids content. This solids content is a mixture of clay, weighting agent, sand and minute amounts of treating chemicals. However, if the mud is at all saline, the computed solids fraction also will contain salt.

A small increase in active clay content can result in a large increase in viscosity. To be of any practical use, therefore, the determination of the total solids content should be sufficiently accurate to estimate a rise in clay content of as little as 1 pound per cubic foot of water base or approximately 0.6 percent by volume.

Mere measurement of the expressed fluids content of a mud employing the retorts available for determining the liquid:solid ratio (API RP.29 4th Edition May, 1957, "Recommended Practice Standard Field Procedure for Testing Drilling Fluids" Section V) is not sufficiently accurate to estimate actual clay content, and this paper is designed to illustrate this point and suggests an alternative procedure.

TABLE 1—Here is the mud solids analysis for two extreme clay contents

MUD WEIGHT		Clay Content Pounds Per Cubic Foot of Water	Specific Gravity Solids	Percent Solids By Volume on Mud	PERCENT CLAY BY VOLUME ON	
Specific Gravity	Pounds Per U.S. Gallon				Mud	Total Solids
1.44	12	3 30	4.026 3.091	14.54 21.04	1.58 14.58	10.85 69.29
1.56	13	3 30	4.068 3.288	18.25 24.47	1.51 13.94	8.27 56.98
1.68	14	3 30	4.095 3.437	21.97 27.76	1.44 13.31	6.56 47.70
1.80	15	3 30	4.115 3.553	25.69 31.34	1.37 12.68	5.34 40.45
1.92	16	3 30	4.129 3.646	29.40 34.77	1.30 12.04	4.43 34.63
2.04	17	3 30	4.140 3.722	33.12 38.20	1.23 11.41	3.73 29.86
2.16	18	3 30	4.149 3.786	36.83 41.64	1.17 10.77	3.17 25.88
2.28	19	3 30	4.157 3.840	40.55 45.07	1.10 10.14	2.71 22.50
2.40	20	3 30	4.163 3.886	44.26 48.50	1.03 9.51	2.32 19.60

Basis of method. Calculations were made on the composition of water/clay/barites mixtures varying in mud weight from 1.4 to 2.4 specific gravity. The specific gravities of clay and barites were taken as 2.6 and 4.2, respectively. The clay concentration was varied between the limits 3 to 30 pounds per cubic foot of water base. Fresh water muds only were considered and the presence of auxiliary treating chemicals, such as thinners, starches, CMC and sand, was ignored.

As mud weight increases the total solids content range decreases . . .

However, sand content is one of the mud properties usually determined daily using the API sieve test. And knowing the sand content helps in deciding whether a solids increase was due to sand alone.

Table 1 summarizes the calculations and gives the mud composition for the upper and lower clay limits. It is at once obvious that, although the clay content varies widely, the percentage by volume of total solids on the mud volume varies over a much narrower range, and as the mud weight increases this total solids content range decreases.

For example, at a mud weight of 18 pounds per U. S. gallon a variation in clay content of from 3 to 30 pounds per cubic foot of water base leads to a total solids percent by volume of from 36.83 to 41.64 percent. Physical determination of the total solids content using the retorts available (in which 10 milliliters of mud are distilled) would result, therefore, in total fluid expressions of 6.3 and 5.8 milliliters, respectively, as measured to the accuracy dictated by the method.

Table 2 takes the calculations still further. It shows the total solids content by volume of muds weighing from 1.4 to 2.4 specific gravity with clay contents varying between 3 and 30 pounds per cubic foot of water base. Examination of this table shows, for example, that at a mud weight of 15 pounds per U. S. gallon (1.8 specific gravity) a variation in clay content from 3 to 10 pounds per cubic foot of water base would result in measured expressed fluid contents of 7.4 and 7.3 milliliters respectively, (on a 10-milliliter sample) and would be 7.1 milliliters at a clay concentration of 20 pounds per cubic foot. Thus, an error in visual measurement of slightly over 1 percent would lead to a considerable error in clay content estimation.

Table 3 relates clay concentration in pounds per cubic foot of water base to the specific gravity of the dried solids.

Suggested procedure. It usually is possible to accurately weigh 10 milligrams even on a rough chemical balance. The suggested procedure depends on whether the mud contains oil. In the absence of oil, the loss in weight when a given volume of mud is heated to dryness is determined. If oil is present, the procedure is a little longer and involves the determination of the density of the dried residue.

The following two precedures apply:

1. Fresh Water Mud (No oil present)—Take a known volume of mud, weigh, heat to constant weight and reweigh. The difference in weight in grams is equal to the volume of water content of the mud from which the total solids percentage by volume may be determined easily. Provided the density of the mud sample is known to an accuracy of 0.01 grams per milliliter (0.08 pounds per U. S. gallon), it is not necessary to know the mud volume taken. Simply take a known weight, heat to dryness and reweigh. Determine the clay content by reference to Table 2, interpolating the result graphically, if necessary, and correcting for sand content, if known.

The constant mud volume container supplied with the available retorts may be used, and, if care is taken in filling, the mud volume is sufficiently accurate for the purposes of this calculation. A large volume requires an inordinate length of time to heat to dryness.

Then % total solids by volume on mud volume

$$= 100\left[\frac{1 - (W_1 - W_2)}{V}\right]$$

or

$$= 100\left[\frac{1 - d(W_1 - W_2)}{W_1}\right]$$

where

W_1 = Weight of mud sample in grams

W_2 = weight of dried residue in grams

V = volume of mud sample taken in mls

d = specific gravity of mud

2. Fresh Water/Oil Emulsion Mud—A known volume of mud (about 50 milliliters) is heated to a constant weight. Determine the specific gravity

TABLE 2—Percentage Total Solids by Volume on Mud

	MUD WEIGHT										
Specific Gravity	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
Pounds per U.S. Gallon	11.67	12.50	13.33	14.17	15.00	15.83	16.67	17.50	18.33	19.17	20.00
Clay Content, lbs. per Cubic Foot of Water Base											
3	13.29	16.40	19.50	22.58	25.69	28.78	31.88	34.97	38.07	41.17	44.26
4	13.56	16.65	19.74	22.83	25.91	29.00	32.08	35.17	38.26	41.35	44.43
5	13.83	16.91	19.98	23.05	26.14	29.21	32.29	35.37	38.45	41.53	44.60
6	14.08	17.15	20.22	23.30	26.36	29.43	32.50	35.56	38.63	41.70	44.77
7	14.35	17.40	20.46	23.52	26.58	29.64	32.70	35.76	38.82	41:88	44.94
8	14.61	17.65	20.70	23.76	26.80	29.85	32.90	35.95	39.00	42.05	45.10
9	14.86	17.90	20.94	23.98	27.02	30.06	33.10	36.14	39.18	42.23	45.26
10	15.11	18.14	21.18	24.22	27.24	30.27	33.30	36.33	39.37	42.40	45.43
12	15.61	18.63	21.64	24.67	27.67	30.68	33.70	36.71	39.72	42.74	45.75
14	16.11	19.11	22.10	25.11	28.10	31.09	34.09	37.09	40.08	43.08	46.07
16	16.61	19.59	22.56	25.53	28.52	31.50	34.48	37.46	40.43	43.41	46.39
18	17.09	20.06	23.02	25.97	28.94	31.90	34.86	37.82	40.78	43.74	46.70
20	17.57	20.51	23.46	26.40	29.35	32.29	35.24	38.18	41.12	44.07	47.01
25	18.75	21.65	24.55	27.44	30.35	33.26	36.16	39.06	41.96	44.87	47.77
30	19.89	22.76	25.62	28.48	31.34	34.20	37.06	39.92	42.78	45.64	48.50

TABLE 3—Specific Gravity of Mud Solids

	MUD WEIGHT										
Specific Gravity	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
Pounds per U.S. Gallon	11.67	12.50	13.33	14.17	15.00	15.83	16.67	17.50	18.33	19.17	20.00
Clay Content, lbs. per Cubic Foot of Water Base											
3	4.007	4.049	4.078	4.097	4.115	4.127	4.137	4.145	4.152	4.158	4.163
4	3.949	4.003	4.040	4.067	4.087	4.104	4.117	4.127	4.136	4.144	4.151
5	3.893	3.958	4.003	4.035	4.061	4.081	4.097	4.110	4.121	4.131	4.139
6	3.840	3.915	3.967	4.005	4.035	4.058	4.077	4.093	4.106	4.117	4.127
7	3.788	3.873	3.932	3.974	4.010	4.036	4.058	4.076	4.091	4.104	4.116
8	3.739	3.833	3.898	3.946	3.985	4.015	4.039	4.060	4.077	4.091	4.104
9	3.692	3.794	3.866	3.918	3.961	3.994	4.021	4.043	4.062	4.079	4.093
10	3.647	3.756	3.833	3.892	3.937	3.973	4.003	4.027	4.048	4.066	4.082
12	3.562	3.684	3.772	3.838	3.891	3.933	3.968	3.996	4.021	4.042	4.060
14	3.482	3.617	3.714	3.789	3.847	3.895	3.933	3.966	3.994	4.018	4.039
16	3.409	3.553	3.659	3.738	3.805	3.857	3.901	3.937	3.968	3.995	4.018
18	3.340	3.494	3.607	3.694	3.765	3.822	3.869	3.909	3.943	3.972	3.998
20	3.276	3.437	3.557	3.652	3.726	3.787	3.838	3.881	3.918	3.950	3.978
25	3.133	3.309	3.444	3.548	3.635	3.706	3.765	3.816	3.860	3.898	3.931
30	3.011	3.197	3.342	3.458	3.553	3.632	3.698	3.756	3.805	3.848	3.886

Construct a graph to determine the daily solid density . . .

of the dried residue (preferably using the gravimetric method detailed in A.10 of Section A.1 of Appendix A "Suggested Procedures for Laboratory Evaluation of Drilling Mud Materials" of API RP. 29). Kerosine is the usual liquid used in the determination which needs to be to an accuracy of only 0.01 grams per milliliter.

Then % total solids by volume on mud volume

$$= \frac{100W_2}{d_2V}$$

or

$$= \frac{100dW_2}{d_2W_1}$$

where

W_1 = weight of mud sample in grams

W_2 = weight of dried residue in grams

V = volume of mud sample taken in mls

d = specific gravity of mud

d_2 = specific gravity of dried solids

If it is necessary to determine the solids density daily, it usually is possible (by using the same gravimetric flask and weight of solids taken) to construct a graph relating density of solids to the final weight of the flask containing the solids and filled with kerosine. This saves unnecessary calculations and is sufficiently accurate. The usual determination of oil and water content by distillation also should be carried out to arrive at a complete analysis.

TABLE 4—Below is shown the resultant mud weight after addition of oil

	BASE MUD WEIGHT										
Specific Gravity	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
Pounds per U.S. Gallon	11.67	12.50	13.33	14.17	15.00	15.83	16.67	17.50	18.33	19.17	20.00
Percent Oil Content By Volume											
2	1.39	1.49	1.58	1.68	1.78	1.88	1.98	2.07	2.17	2.27	2.37
4	1.37	1.47	1.57	1.66	1.76	1.86	1.95	2.05	2.14	2.24	2.34
6	1.36	1.46	1.55	1.65	1.74	1.83	1.93	2.02	2.12	2.21	2.30
8	1.35	1.44	1.54	1.63	1.72	1.81	1.90	2.00	2.09	2.18	2.27
10	1.34	1.43	1.52	1.61	1.70	1.79	1.88	1.97	2.06	2.15	2.24
12	1.33	1.42	1.50	1.59	1.68	1.77	1.86	1.94	2.03	2.12	2.21
14	1.32	1.40	1.49	1.57	1.66	1.75	1.83	1.92	2.00	2.09	2.18
16	1.30	1.39	1.47	1.56	1.64	1.72	1.81	1.89	1.98	2.06	2.14
18	1.29	1.37	1.46	1.54	1.62	1.70	1.78	1.87	1.95	2.03	2.11
20	1.28	1.36	1.44	1.52	1.60	1.68	1.76	1.84	1.92	2.00	2.08
25	1.25	1.33	1.40	1.48	1.55	1.63	1.70	1.78	1.85	1.93	2.00

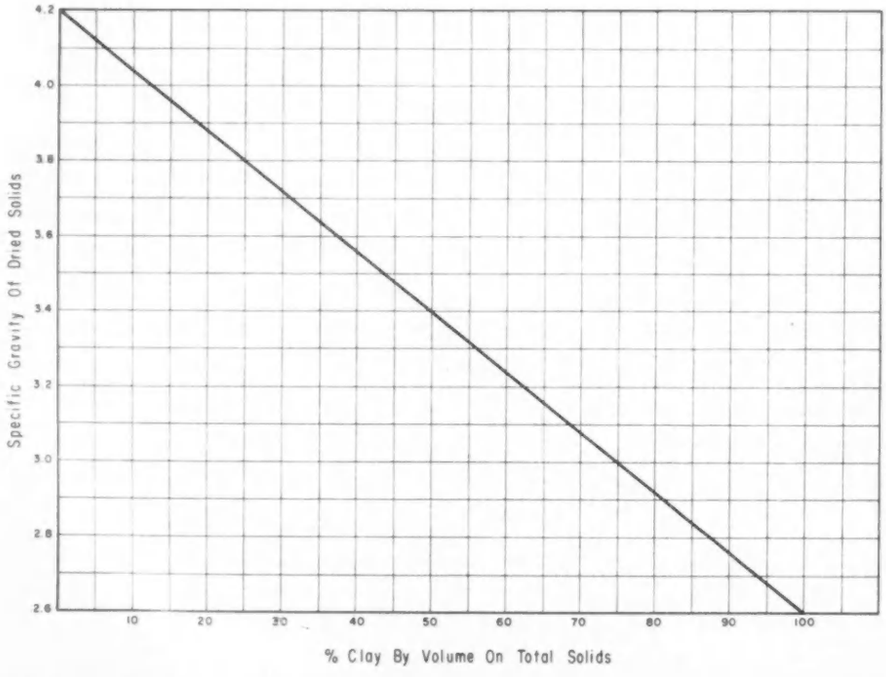


FIGURE 1—This figure is a straight line function of specific gravity of dried solids vs. % clay by volume on total solids.

Since a mud (of fixed clay content on water base) containing oil as part of its fluid phase must necessarily contain a greater barites content for a given mud weight than one without oil, it is not possible to use Table 3 directly to determine the clay concentration of the water base in terms of density of total solids. Consequently, it would be necessary to recalculate Table 3 for various oil concentrations.

To overcome this difficulty two approaches are possible:

1. From a knowledge of the oil content by volume (determined by the usual retort method) calculate the density of the base mud in the absence of oil by reference to Table 4 and then use Table 3 relating clay concentration of water base to the density of the dried solids *for the base mud density figure* and not the actual density of the oil emulsion mud.

2. Determine the concentration by volume of clay on the total solids volume by reference to Figure 1 which relates dried solids density to clay percentage by volume on solids and obviously is a straight line relationship. Knowledge of the total solids content by volume on the mud (from total solids weight and density of dried solids) and the volume ratio of water: oil: solids may then be used to calculate the clay content per cubic foot of water base.

Method 1 gives the actual clay content of the mud in terms of pounds per cubic foot of water base, which is the main factor affecting viscosity. Method 2 without lengthy calculations will show whether the clay content is increasing in terms of the clay: barites ratio.

Discussion of calculations. Figure 2 is a composite diagram relating mud weight to total solids content by volume on mud for varying clay contents of water base. The lines for clay/water and barites/water mixes are also included and obviously represent the maximum and minimum solids content by volume respectively for any given mud weight.

The figures along the clay line indicate the concentration of clay required in pounds per cubic foot of water to produce a given mud weight. Similarly, the figures along the barites

At high mud weights the toleration to clay solids is low . . .

line indicate the quantity of barites required in pounds per cubic foot of water to yield a given mud weight, as do the figures located at random on the clay/barites mixture lines.

These latter figures illustrate the reduction in barites content for a given mud weight as the clay concentration increases. For example, at a mud weight of 14 pounds per U. S. gallon, the barites requirements in pounds per cubic foot of water base is as shown in the following table:

1	2
0	70
3	69
10	65
20	59
30	53

1. Clay content of base in pounds per cubic foot. 2. Barites required in pounds per cubic foot of water base to give a mud weight of 14 pounds per U. S. gallon (1.68 specific gravity).

It is not possible to draw two lines on this figure to represent respestively the minimum and maximum clay contents recommended for a given mud weight. The position of such lines obviously must depend on the mud type. However, at high mud weights, regardless of mud type, the toleration to clay solids is low, and both maximum and minimum clay solids lines will approach the barites line in the high weight mud region.

For a high lime mud, the clay toleration is extremely good and a mud weight of around 1.4 specific gravity (11.67 pounds per U. S. gallon) usually can be attained without addition of barites and still exhibit good rheological properties. The maximum recommended clay solids content of such a lime mud, therefore, would be represented by a curve similar to the one shown in the diagram.

The minimum clay solids line could be determined only by noting at what clay concentration (for a given mud weight) the barites fraction commenced to settle out on account of insufficient gel structure.

The use of this kind of diagram is recommended when heavy mud programs are in operation and a solids analysis is a daily feature of mud testing. Plotting the daily mud solids data on such a diagram can lead to a better understanding of variations in mud viscosity with clay content. It should result in a better appreciation of the influence of even small increases in the amount of active clay.

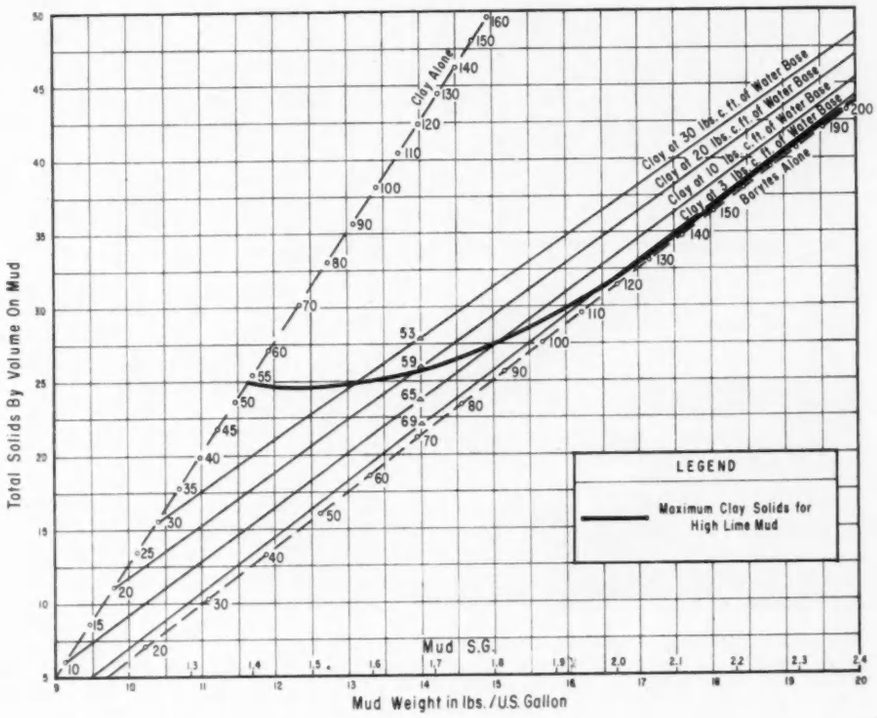

Total Solids By Volume On Mud
Mud Weight in lbs. /U.S. Gallon
Mud S.G.
Clay Alone
Clay at 30 lbs. c. ft. of Water Base
Clay at 20 lbs. c. ft. of Water Base
Clay at 10 lbs. c. ft. of Water Base
Clay at 3 lbs. c. ft. of Water Base
Barites Alone
LEGEND
Maximum Clay Solids for High Lime Mud

FIGURE 2—This figure graphically shows the clay solids content of mud vs mud weight. The curved line illustrates the maximum clay solids for high lime muds.

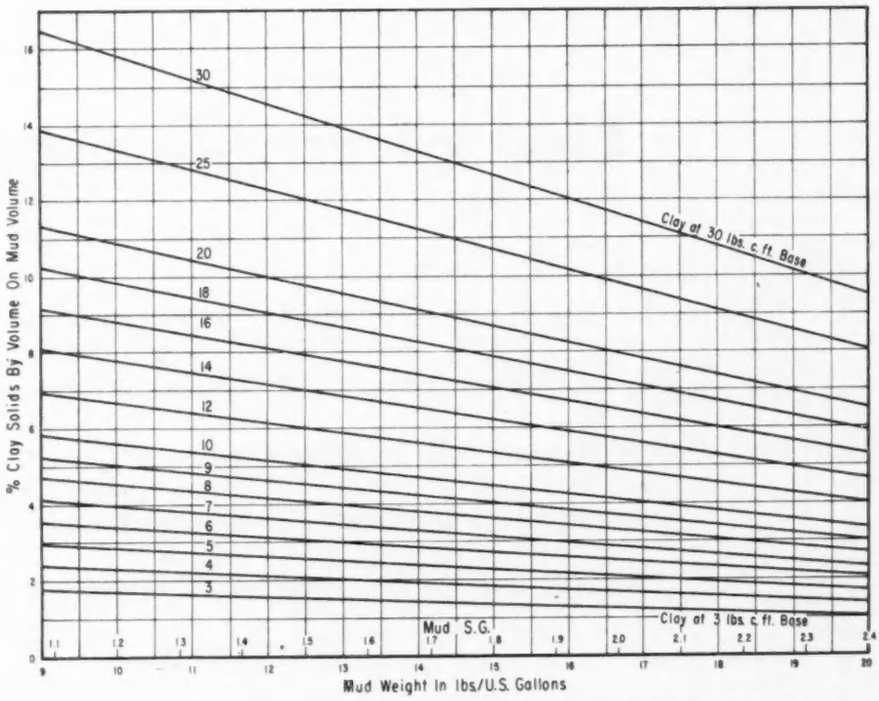


FIGURE 3—This figure shows the mud weight and clay solid content by volume on mud for various contents of the water base.

Figure 3 relates mud weight and clay solids content by volume on mud for various clay contents of the water base.

—The End

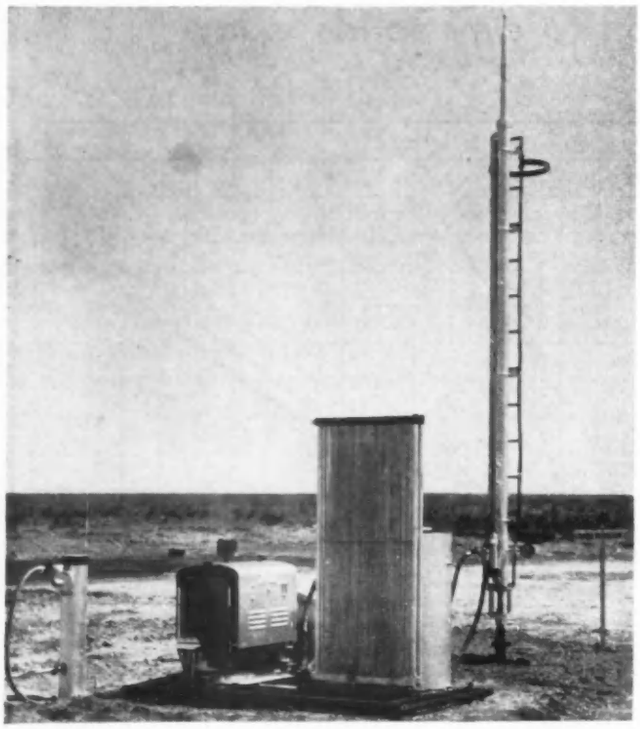


FIGURE 1—Stekoll Petroleum Company currently completes small cased wells in the 5,000-foot depth range with a 12-foot stroke, hydraulic pumping unit as shown here. A 12-foot pup joint is included in the 1-inch pumping string. Each time a pulling job is performed on the well, the pup joint is moved to a different position in the 1-inch string to distribute wear over the entire casing string.

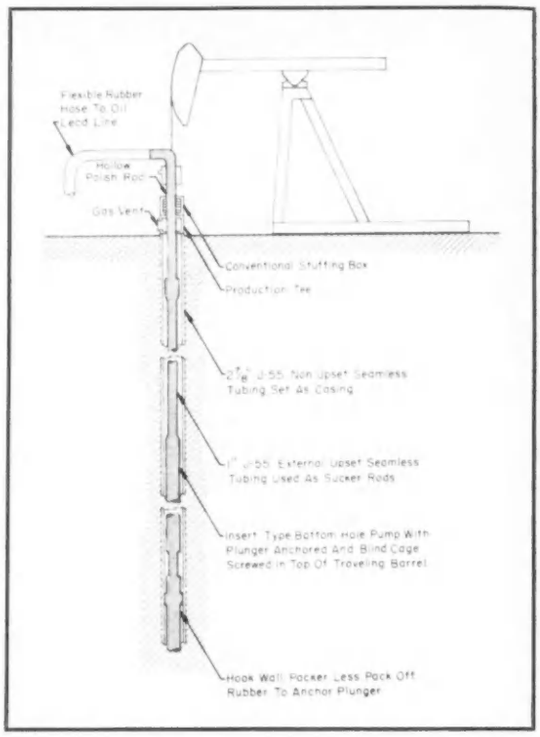

Flexible Rubber Hose To Oil Lead Line
Hollow Polish Rod
Gas Vent
Conventional Stuffing Box
Production Tee
2⅞" J-55 Non Upset Seamless Tubing Set As Casing
1" J-55 External Upset Seamless Tubing Used As Sucker Rods
Insert Type Bottom Hole Pump With Plunger Anchored And Blind Cage Screwed In Top Of Traveling Barrel
Hook Wall Packer Less Pack Off Rubber To Anchor Plunger

FIGURE 2—This schematic drawing shows how 1-inch tubing is used in lieu of a rod string in a slim hole completion. Well fluid is pumped through the interior of the 1-inch pipe to surface.

Use of small diameter casing

Successful slim hole completions are dependent on proper engineering considerations. Five thousand-foot wells equipped with 2⅞-inch casing are completed for approximately $8,000 less than similar wells equipped with 5½-inch casing

By Marion H. Stekoll, President
W. L. Hodges, General Superintendent
Stekoll Petroleum Co., Dallas

STEKOLL PETROLEUM COMPANY has reduced well completion costs by setting 2⅞-inch casing (oil strings) in lieu of larger pipe. One-inch tubing also is used in these slim hole completions in place of conventional rod and tubing strings. Comparisons of well costs indicate that a typical 5,000-foot well will cost $7,500 to $8,500 less when equipped with 2⅞-inch casing than a well completed with 5½-inch pipe. This saving means that enough money is saved to drill another well with approximately every seven wells drilled.

It is the practice of Stekoll Petroleum to use small size casing in producing oil wells as a proper and economical engineering procedure. This article outlines field case histories of such practice and delineates procedures and experiences with the

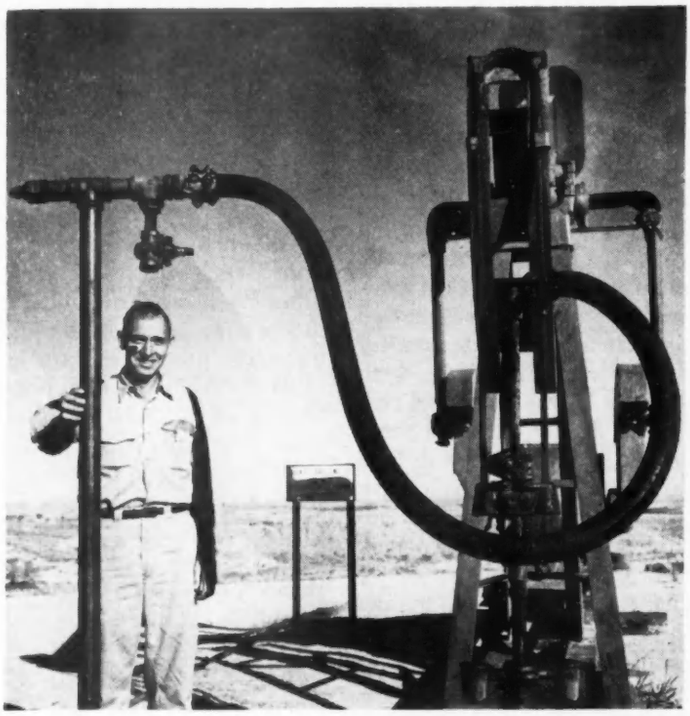


FIGURE 3—The 1-inch pumping string is connected to the flow line riser as shown here. Since the 1-inch pipe is reciprocated in the same manner as a rod string, a flexible rubber hose must be used to connect the 1 inch and the flow line. The union near the 1 inch tie-in allows the hose to be easily and quickly disconnected from the flow line.

reduces well costs

use of small casing over a 15-year period. Experience and complete engineering studies indicate that small size casing is completely suitable, under proper conditions, not only for edge wells but also for wells in the center of a field. There are no hazards nor difficulties in the use of small casing. The use of such casing is merely another step of progress in the oil producing industry.

Slim hole completion methods must not be confused with that of slim hole drilling. The use of small size casing in wells may or may not be related to a reduced hole. Obviously, the use of smaller size casing permits the drilling of a smaller hole, but the smaller hole may not be economic for any of several reasons. An operator interested in completing wells economically is interested in a smaller size hole only if it reduces the cost of the well. For example, it is normal practice in the Borger, Texas, area to drill a 6¼-inch hole from the 7-inch surface casing seat to total depth. When drilling contractors are not properly equipped or where formations are not suitable, a smaller hole may be more expensive than drilling a standard size well.

The purpose of completing a well with smaller size casing than that which normally is used is simply to reduce the investment costs of a well. The main objection to completing a well in this manner has been a fear that workover jobs cannot be performed adequately and that the well cannot be drilled deeper if the occasion arises.

Undoubtedly a basis once existed for the fears mentioned, but with modern equipment it is possible to perform almost any necessary workover job in small diameter pipe. It is correct that smaller size casing does prohibit drilling deeper if a substantial amount of additional hole is required. However, the number of wells in which this situation is significant is comparatively small and does not prohibit use of small size casing in many areas where it can afford substantial saving over standard completion methods.

Experience. Accepted use of 5-inch casing is of comparatively recent date. In the late 1920s, it was customary in the Panhandle field of Texas to use as many as six sizes of casing in a cable tool drilled well. These casing strings ranged from 20-inch or 24-inch O.D. down to 7- or 8-inch O.D. These wells are approximately 3,000 feet in depth. In the early 1930s, Stekoll Petroleum Company completed approximately 10 wells with 5-inch casing. While no difficulties were encountered, there was no adaptation of the 5-inch casing program by other producing companies in the area. Therefore, the company reverted to the use of 7-inch pipe for several years until such time as 5-inch pipe became a standard and acepted size. At that time, 4½-inch casing was not considered even as feasible in this area.

The trend in the producing oil industry has been one of gradually reducing the amount of steel installed in wells. With improved technology, 5-inch casing became a standard instead of 7-inch or 8-inch casing. Today, the use of 4½-inch casing is well accepted. The use of 2½-inch casing has been proven by our organization and by others in the last five years. Also, there is increasing interest by other companies in 2½-inch casing.

In 1942, Stekoll Petroleum Company started a water-flood in the Bolton field, Montgomery County, Kansas. The sand in this area lies at approximately 1,000 feet in depth and the property was developed as a flowing-type water-flood. Investigation indicated that it was customary to use 4-inch or 4½-inch casing for the water injection and producing wells.

The cost of completing wells with 4- or 4½-inch pipe was compared to the cost of completions using 2-inch pipe. It was found that the additional investment capital required for the large casing would amount to a sub-

stantial additional investment in the property. Since the wells were only 1000 feet deep it was decided that 2-inch pipe would be used for casing in the wells. Also, since pressures would not be excessive, 2-inch line pipe was used instead of 2-inch tubing. The company was able to complete three wells (using 2-inch line pipe for casing) for the cost of two wells using 4½-inch casing.

In the past 15 years, more than 1,000 wells (producers and injection wells) have been drilled by Stekoll to the 1,000-foot depth. No unusual difficulties have been encountered through the use of small pipe. Necessary bailers, sand pumps and drilling bits have been made to operate inside the 2-inch so that squeeze cementing jobs, etc., can be performed satisfactorily. Workover jobs in small pipe have been completed at less cost than would have been encountered in larger casing.

In development of another Kansas water-flood operation, a program of wider spacing and pumping of producing wells was used. It was decided that an attempt would be made to pump wells through 2-inch "casing" by using 1-inch line pipe as tubing and rods. Engineering calculations indicated that this should prove satisfactory. Through cooperation of the pump companies, a bottom hole insert type pump was adapted that could be used with 1-inch line pipe. Results for the past 12 years have indicated no increase in lifting cost through the use of this equipment. Necessary fishing and repair tools have been developed for use inside of 2-inch pipe and all repair jobs have been accomplished as successfully as with conventional type pumping wells.

In the Kansas area, an adjacent water-flood property was purchased that covered several sections. Wells on this property had been completed with 4½-inch casing. A comparison of the two areas showed approximately the same barrels per acre-foot oil was recovered by both properties, one with 4½-inch casing and the other with 2-inch line pipe as casing. Furthermore, lifting costs were somewhat less in the small cased wells because workover problems were handled with less expense.

From 1950 to 1955, several hundred injection and producing wells were drilled in the Corsicana (Texas) water-flood operations to a depth of approximately 1,200 feet. The use of 2-inch line pipe for casing on both injection and producing wells and the use of 1-inch line pipe as a pumping string in the pumping wells was continued. Operation of the equipment in Corsicana has proven satisfactory.

In 1954, Stekoll Petroleum Company entered into renewed drilling operations in the Panhandle field, Hutchinson County, Texas. Cost analysis of drilling wells by the standard method indicated prohibitive cost for the productive capacity of the wells in this old field. It was concluded that the only way a drilling program could be carried out successfully in this field would be to reduce investment costs of new wells. Engineering calculations indicated that it would be necessary to increase casing sizes from 2-inch to 2½-inch. Also, 2½-inch tubing would be required for casing instead of 2½-inch line pipe. Tubing was necessary due to development of frac procedures and the resulting higher pressures imposed on the casing string.

It also was calculated that 1-inch upset tubing would be required for the pumping string in order to satisfactorily withstand loads imposed by the 3,000-foot depth. To determine if the 1-inch would operate satisfactorily, rods were pulled out of an old producing well and replaced by 1-inch upset tubing. This tubing was operated for more than three months to determine if operational difficulties would develop. The experiment was concluded successfully, and a well was drilled using 2½-inch tubing as casing. This well was operated for six months before additional wells were drilled. This experiment likewise proved successful and to date more than 20 wells have been completed with small casing without operational difficulties.

The success of several years of operation at 3,000-foot depths with small casing, prompted Stekoll Petroleum Company to attempt the completion method at greater depths. The first 5,000-foot well completed with 2½-inch casing was Stekoll Petroleum Company, Frost 1, Cochran County, Texas. (Figure 1) This well has been pumping for seven months using a hydraulic type surface pumping unit. There have been no operational difficulties due to the use of small casing. An additional 25 producing wells (15 pumping) have been completed to 5,000 feet in Canada. These installations also have been satisfactory.

Field Operations. It is of interest to mention some operational procedures and equipment used when a well is completed with 2½-inch casing.

One-inch upset tubing, as mentioned previously, is used as the pumping string. The tubing is handled in the same manner as rods as far as pumping procedures are concerned. (Figure 2) When the pump at the bottom of the well requires replacement or repair, it is necessary to pull the 1-inch pipe in the same manner as it is necessary to pull rods. The weight of the 1-inch pipe is of the same magnitude as rods used in a well of comparable depth. Time studies indicate that it takes 10 to 15 percent more time to pull the 1-inch pipe from the well than it does to pull rods. This is a small factor and additional equipment and changes are being considered to reduce even this small difference. However, this small difference is more than offset by the fact that there are no tubing jobs in a well that pumps through 1-inch pipe, since the 1-inch acts both as tubing and rods. When tubing jobs on a normal well are considered, it is apparent that the total cost of pulling the 1-inch out of small cased well is considerably less than having to pull both rods and tubing on a conventional completion. Figure 3 shows a typical surface installation for a well pumping through 1-inch pipe.

Wells in the 5,000-foot depth range now are equipped with a 12-foot stroke hydraulic pumping unit. A 12-foot pony joint is moved each time the 1-inch is pulled, so that casing wear that may occur is distributed over the entire casing string. With this distribution of wear, it is estimated that the casing will long outlast the productive life of the well. Operational history over the past 12 years indicates this to be a fact.

Wells are pumped with standard insert type pumping barrels. There is no basic change in this equipment as compared to a conventional rod pump installation in a tubing string.

A hookwall anchor has been developed so that little or no operational difficulties arise in its use. It has been used for more than 10 years in several hundred wells and minor improvements made from time to time have developed the anchor to its pres-

ent satisfactory status. There are, therefore, no seating nipples nor restrictions in the casing whatsoever. The casing is full-open from the surface to total depth.

It now is possible to perforate satisfactorily in 2½-inch casing, squeeze cement such wells and drill out the cement at low cost. Experience has shown that all normal well workover jobs can be done through the small diameter pipe. Also, they can be done cheaper and easier. Generally, workover jobs in small casing can be handled with smaller equipment, less manpower, less moving costs, smaller tools and reduced volumes of workover fluid. In some instances, workovers may be done in small cased wells where they might not be attempted in the larger holes due only to the economics involved. Therefore, oil may be recovered that might otherwise remain in the ground.

A number of cement squeeze jobs have been completed successfully in 2-inch and 2½-inch casing. Records show that over 50 jobs have been completed at depths ranging from 1,000 feet to 5,000 feet. These squeeze jobs were performed at considerably less cost than a comparable job in a well equipped with 5½-inch casing. Also, they were done with much less mechanical difficulty. At depths ranging from 3,000 to 5,000 feet, 300 feet of cement may be drilled out in a 24 hour period.

To drill out 100 feet of cement costs approximately $200. This price includes power swivel, bits, pits, pumps, etc. It does not include the pulling unit. This is a contract cost which is higher than would be incurred if the operator owned the equipment. Since smaller equipment is needed, it is economical to purchase necessary equipment under extensive operational conditions. When cement is drilled out and related services are done with company equipment, costs are reduced considerably. In the authors' opinion, the larger investment required to do this work in 5-inch casing prohibits purchasing equipment and requires the use of contract machines with resultant higher costs. The cost of a complete cement squeeze job (drilling out included) is often twice as much in 5½-inch pipe as compared to 2½-inch jobs.

Acidizing and fracturing procedures are accomplished satisfactorily in 2½-inch casing. Several hundred wells have been fractured through 2½-inch pipe. Jobs performed through 2½-inch casing require considerably less breaking fluid and flush fluid. This results in a more economical operation.

Consideration should be given to strength problems of the 1-inch pipe. A review of the analysis of J-55 and N-80 1-inch upset tubing indicates metallurgical strength considerably above that required for the imposed loads. At a depth of 3,000 feet, conventional beam pumping units have been pumping approximately 70 barrels fluid per day through the 1-inch string of pipe. Three to four years' experience (20 wells considered) shows that the wells have a parting job approximately once in two years. This experience is as good or better than that found with rods in the same field. At 5,000 feet, the use of hydraulic units with slow pumping speeds probably will result in fewer parting problems than that found in the 3,000-foot wells pumping at higher speeds.

Studies indicate lifting costs of approximately $3.10 per day per well for 3,000-foot completions with 2½-inch casing. These lifting costs are comparable with more than 100 other wells in the same field on adjoining leases which are completed with tubing and rods. This cost includes field engineering and supervision, as well as other field expenses. It may be concluded that the cost of operating wells with 1-inch pipe as the pumping string is no greater that the cost of conventional rod installations.

If a hole occurs in the casing for any reason, the usual procedure is to wash over the 2½-inch casing with larger pipe down to the top of the cement. Recovery of the 2½-inch pipe above the top of the cement is accomplished by backing off the 2½-inch above the cement with a left hand fishing string. When the pipe with the hole has been removed, it is replaced with new 2½-inch pipe and re-installed in the well. The washover string then is removed. This procedure will seldom be used, as the need for it occurs only in rare cases. If the occasion does arise, the procedure can be used without undue complications.

If bottom-hole pressure tests are required, it is necessary to pull the 1-inch pumping string. This is comparable to pulling rods in conventional completions where rods also must be pulled in order to measure bottom hole pressures. In addition, recording bombs have been run on the bottom of the 1-inch pipe below the pump to obtain bottom hole pressures while pumping.

Practically all down hole well equipment and services are available now in sizes suitable for running inside 2½-inch casing. A partial list of such services and equipment follows:

1. Temperature surveys
2. Perforating guns, both jet and bullet type

About the Authors

Stekoll

Marion H. Stekoll is a graduate of Stanford University and was for three and a half years an employe of Core Laboratories in Dallas. In 1942, he resigned from Core Lab. to go into business with his father and became president of Stekoll Petroleum Company in 1951.

By testing operational theories in the 60-year-old Bolton field near Independence, Kan., and in the 64-year-old Corsicana Shallows field in Central Texas, Stekoll pioneered innovations in water-flood proceduces which have become common practice in other fields.

Stekoll began developing slim-well completion and workover techniques in Borger, Texas. He has further advanced the techniques in West Texas and in Canada. Stekoll has completed more than 50 wells in Canada, has development programs under way in Texas and Kansas, and has recently announced the extension of operations into Venezuela.

W. L. Hodges, general superintendent of Stekoll Petroleum Company, first joined the independent oil and gas producer at Independence, Kan., in 1945 following his discharge from the Air Force. A native of Caney, Kan., who entered service after two years in college, Hodges advanced within a year to field engineer and then chief engineer before being transferred to Corsicana, Texas, as superintendent of the Stekoll operations there. Hodges was promoted to general field superintendent for Stekoll in the summer of 1957 and has been in charge of Canadian developments since early in 1958.

An itemized inventory of all costs of a typical 3,000-foot slim hole completion in the Panhandle area of Texas . . .

TABLE 1

SURFACE EQUIPMENT	Amount
7" OD 8rd. casing head	24.00
7" OD x 2½" tubing hanger	54.50
5 HP, 1,200 rpm electric motor	188.04
2" hose w/couplings	57.69
Pumping unit	1,863.20
Gear oil for unit	15.28
Connections & valves for lead line	103.46
Chain, load binder, anchor	28.10
5.0" sheave	9.29
Motor control w/clock & arrestor	156.00
Hook up motor, control & line	342.00
7" pipe for frame for pumping unit	40.00
3" x 12" x 4' boards for pumping unit	14.70
V belts	12.08
1 5/16" polished rod clamp	16.10
2½" reg. pumping tee	5.75
2½" reg. x 2" reg. swage nipple (2)	5.68
1¼" x 72" polished rod liner	38.70
Polished rod liner head	9.85
1¼" polished rod lubricator	24.75
2½" x 1¼" stuffing box	15.25
2" line pipe—920'	347.78
Total	**3,372.20**
Sub-Surface Equipment	
Centralizers (7)	154.70
Scratcher (30)	197.10
3½" EUE tubing float collar	83.30
2" x 1½" x 9' pump w/50 ring plunger	202.49
2½" x 12" plastic guide	24.81
2½" Anchor	132.93
1¼" x 12" pump strainer	4.40
Bleeder valve complete	9.99
Total	**809.72**
Casing-Tubing Shoe	
7" OD 8rd. casing shoe	20.35
7" OD 8rd. x 6' casing nipple	9.83
2½" EUE tubing couplings (4)	13.57
7" OD S.H. casing—337'	589.75
2½" reg. tubing—3285'	2,697.62
1.315" OD EUE tubing—3152'	1,388.33
1.315" tubing plastic coated	536.32
2½" reg. to 3½" EUE swage	20.00
Baffle plate	1.30
	5,277.07
Sold thread protectors.....Credit:	10.62
Total	**5,266.45**
Hauling	
7" OD casing to well	41.00
Haul and string 2" line pipe. Haul and set unit	34.17
Oil for mud plus oil	151.00
Haul 60 barrels hot salt water. Haul 945 barrels hot salt water. Move frac tanks	818.84
Haul 400 barrels oil & fracture	265.74
1" tubing to well	19.93
Steam acid and test tank	35.00
Total	**818.84**

SURFACE EQUIPMENT	Amount
Surveying	
Make location	33.33
Ran elevation	5.00
Total	**38.33**
Grading	
Build road	48.00
Grade for pipe line	12.00
Fill pits, make grade at well	108.00
Grade off location; build road; grade for pipeline; put caliche on location & road	280.00
Total	**448.00**
Drilling	
Drill well—3258'	9,285.30
Total	**9,285.30**
Geological Service	
Sand sample bags	4.50
Geological service	200.00
Total	**204.50**
Cement	
Cement 7" OD casing (Service)	158.30
Cement for 7" OD casing	211.48
Cement for 2½" casing	204.84
Cement 2½" casing (Service)	334.70
Aluminum powder	6.38
Total	**915.70**
Fracing & Perforating	
Perforate well	125.00
Bottom hole temperature test	341.50
150 gal. 15% acid	39.00
Sand for fracturing	187.80
Fracture well	1,338.16
Total	**2,031.46**
Swabbing-Sand	
2½" swab cup rubbers	17.80
Rent sand line & 2" drilling tools	69.14
Pulling unit: 3 hrs.	13.50
Labor less supervision	66.26
Total	**166.70**
Car-Truck-Pulling Unit Rent-Labor	
Car mileage—503 miles at .08 per mile	40.24
Labor less supervision	82.20
Pulling unit: 4 hours @ 4.50	18.00
Total	**140.44**
Welding & Machine Work	
Cut & weld to install scratchers & centralizers	18.00
Build base & install on unit	24.00
Total	**42.00**
TOTAL	**$23,539.64**

TABLE 2—Here are comparative equipment costs of wells drilled to approximately the same depth in Canada. Note the substantial savings indicated by the slim hole completion method.

Well No.	Size, Quantity and Cost of Surface Casing	Size, Quantity and Cost of Oil String	Size & Cost of Tubing	COST: Scratchers and Centralizers	COST: Wellhead Assembly	Total Cost
1	10¾", 500' 2,185.00	7", 4500' 11,250.00	2⅞" 4,685.00	500.00	2,200.00	20,820.00
2	10¾", 500' 2,185.00	5½", 4500' 8,100.00	2⅞" 3,555.00	480.00	2,143.00	16,463.00
3	5⅝", 500' 1,480.00	4½", 4425' 5,625.00	2⅞" 3,555.00	420.00	2,100.00	13,180.00
4	8⅝", 500' 1,480.00	2⅞", 4500' 4,005.00	None	500.00	596.00	6,581.00

3. Gamma ray logs
4. Tracer surveys
5. Drilling bits and drilling tools
6. Complete assortment of fishing tools
7. Sand pumps and bailers (frac sand is removed easily)
8. Hook wall packers and anchors

This list is incomplete, but it is indicative of the technology of the producing oil industry and shows that operation of producing wells in 2½-inch casing may be considered a routine procedure.

There is considerable saving in well completion costs by using 2⅞-inch casing as compared to 5½-inch pipe. Table 1 contains a complete breakdown of costs in drilling and completing a typical 3,000-foot well by slim hole method. The 1-inch tubing replaces both the usual tubing string and rods. In addition, well head fittings are smaller and cheaper. Comparisons indicate that a 5,000-foot well will cost $7,500.00 to $8,500. less with 2½-inch casing than a well completed with 5½-inch casing. This difference means that enough money is saved to drill another well with approximately every 7 wells drilled. Table 2 compares the costs of several conventional wells in Canada to a typical slim hole completion in the same area.

Dual completions are possible with 2½-inch pipe by cementing two separate strings of casing in the hole. Recent developments allow perforating of the second string without damage to the first. No packers are required in this type of dual as compared to conventional wells.

Conclusions. Success in the use of 2½-inch tubular goods as casing is dependent upon application of proper techniques in the field, as well as use of proper equipment. With proper field procedures, no difficulties need be encountered that are not found in completions with larger casing. Basically, well completion problems now are solvable in 2½-inch and 5½-inch casing by similar methods, but with some variation in technique. Engineering analysis of materials and equipment indicate that 2½-inch casing is adequate in wells under proper conditions.

It is the authors' opinion that, under proper conditions and supervision, the use of 2½-inch as casing will increase greatly in the near future.

—The End

PART 7: DISCHARGE LINE DAMPENERS

Know your mud pump—it can save you money

Dampeners CAN correct normal surges in discharge system

By Samuel L. Collier, Research Engineer
Mission Manufacturing Company, Houston

A DEVICE put in the mud pump discharge line to reduce pressure variations can increase rig hydraulic power output, cut maintenance costs and improve over-all operations.

How are surges developed? Variation in flow rate caused by the piston of a power pump results in a fluctuation in the line pressure. The fluctuation occurs within the mud pump, the surface piping system and the drill string. Since the mud is highly incompressible and the heavy piping is quite rigid, it will be difficult for the system to accommodate these changing flow rates. The pressure will vary with an increase or decrease in fluid rates. This is the regular normal surge in discharge pressure, and the dampener is intended to correct these long normal surges. Although a pulsation dampener may help alleviate the bad effects of water hammer, the usual dampener is not designed or located to handle this water hammer problem.

Little evidence of the normal regular development of water hammer was obtained in the mud pump laboratory tests on the discharge system. The continuous flow rate change characteristics of a power pump partially causes the rise and fall in pressure due to inertia. However, these changes are small compared to the total discharge pressure. The water hammer pressure due to a sudden change in flow of 2 or 3 feet per second would be 120 to 180 psi.

Generally, sudden changes of this nature do not occur in the pump discharge system. Unusual conditions

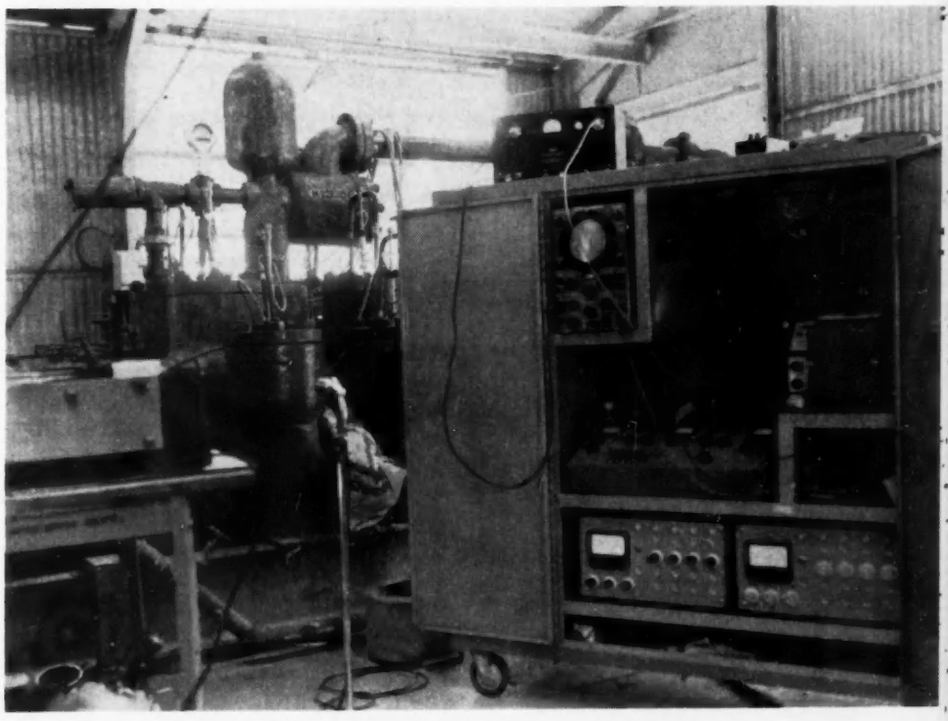


FIGURE 37—Oscillographic test is shown of a pump equipped with an atmosphere air chamber.

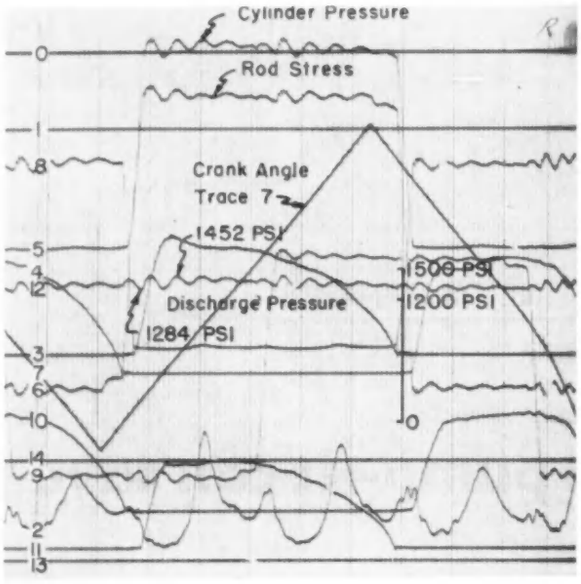


FIGURE 38a—A properly installed dampener will reduce surging 82 percent.

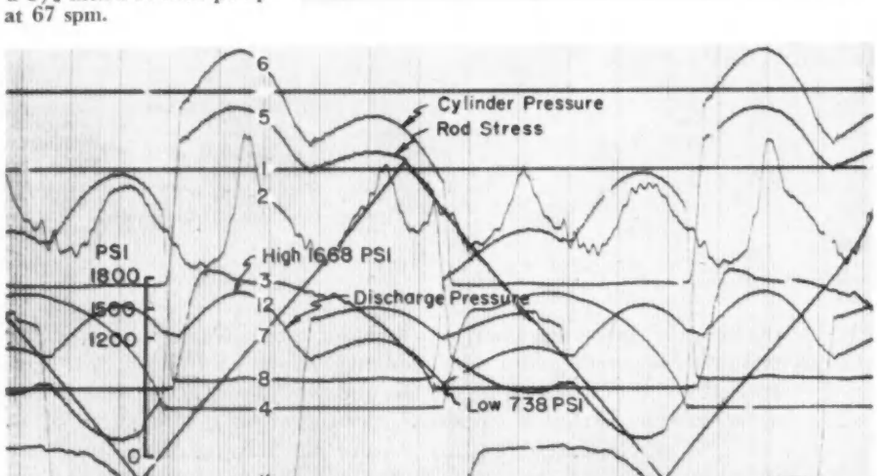


FIGURE 38b—Large normal surges are shown from a 5½-inch x 14-inch pump at 67 spm.

causing shock greater than simple water hammer must have occured to cause some of the damage that has been reported in the field. Consequently, these failures are difficult to reproduce for laboratory study.

Dampeners reduce surging. Various types of devices can be installed in the discharge line to accommodate this changing flow rate. Devices of this nature have been called dampeners, desurgers, neutralizers, accumulators and snubbers.

Major operating feature of these devices is to eliminate or reduce the surge in line pressure. It usually is based on:

- Compression of a small gaseous volume
- Throttling orifices
- Cancellation by tuning

The design of a device that will perform efficiently is complicated. Therefore, assistance from the manufacturer should be obtained for proper selection. An occasion may arise whereby an expedient type of dampener is necessary, so for best results the following principles should be followed.

One of the most successful methods of reducing pulsation is the use of an air chamber consisting of an air trap. For very low pressures, the air chamber works very efficiently. However, since the air trapped in the chamber is atmospheric air, it will be compressed to a much smaller volume than that of the vessel when the pump speed is increased. If the vessel contains one cubic foot of air at atmospheric pressure and the mud pressure increases to 135 psi, the air will be compressed to 0.1 cubic foot. At this pressure, the air chamber works satisfactorily. At 1,500 psi, a normal pressure operating range, the air would be compressed to 0.01 cubic foot (17 cubic inches). Thus, a surge from the pump of about 8 cubic inches flowing into such a chamber would result in a 3,000 psi pressure of the trapped air. In other words, the chamber is not effectively dampening the surge.

The mud pump shown in Figure 37 was tested with the air chamber completely flooded and with a full volume of air trapped within it. Oscillograph records of the pump under various operating pressures from 700 psi to 2,000 psi showed no evidence of effective dampening. Dampener efficiency may be checked by oscillographic records of the discharge pressure.

How well does a dampener work? An indication of the effectiveness of a discharge pulsation dampener can be easily obtained by observing the discharge pressure with oscillographic charts or visual observation of the pressure gage. Oscillographic readings of the pressure are much more accurate. Figure 38a and b is a recording taken from a 5½-inch x 14-inch mud pump at 60 spm at approximately 150 psi discharge pressure. Comparison of Figure 38a with Figure 38b, a similar test run without the dampeners, shows several definite characteristics.

- The discharge pressure is smoother and nearly flat
- The cylinder pressure is smoother and nearly flat
- The discharge and cylinder pressure fluctuate oftener than without the dampener
- The stress in the pump rod follows the new discharge pressure pattern
- The motion of the valves is unchanged
- The suction pressure is unchanged

Some factors are fairly evident, but test data confirm anticipated results. There should be no effect on the suction side of the pump by the use of a discharge pulsation dampener. Nor should the dampener affect the suc-

tion surges. The pump valves completely separate the discharge and suction system from one another. The pattern of motion of the valves is determined by the pattern of motion of the piston which did not change in these tests. Since the valve indicates the flow rate from the cylinder, the pattern was unchanged.

The oscillograph record trace 7 is the crank angle. When this is a straight line, the crank angle is changing linearily with time or the rpm is constant throughout the stroke. Incorporating V-belt drive and sufficient power, the rotation will be steady. However, if the engine or the drive allows slight variation in rotation speed, a dampening action on the discharge pressure could result. The V-belt drive used in these tests has practically no dampening action.

In Figure 38a and b, the operating pressure was sufficiently higher than the dampener charge pressure to obtain the most efficient operation.

Figure 39 is an oscillograph record taken in the same test series at about 700 psi discharge pressure. This is about the same as the dampener charge pressure. Under these conditions, the dampener fails to reduce the surge and the pressure pattern will resemble a system which does not employ a dampener.

Position of device. The above results were obtained with the device in an ideal location. Improper location of a dampener not only will reduce the efficiency but also could actually increase the surge amplitude above that obtained with no dampener. Location is more important at higher speeds.

Figure 41a is an oscillograph record of the discharge pressure from a 4 x 8 triplex plunger pump at 174 spm. The (Figure 40a) pressure surge with no dampener in the line fluctuates between 2,210 psi and 1,675 psi. For efficiency, the dampener was first installed about 25 feet from the pump. Severe vibrations of the piping caused a number of pipe failures. An oscillograph record (Figure 40b) of the discharge pressure showed that the pressure was surging from 2,595 psi to 1,460 psi when the other operating conditions were the same as for Figure 41a. The pump pressure gage

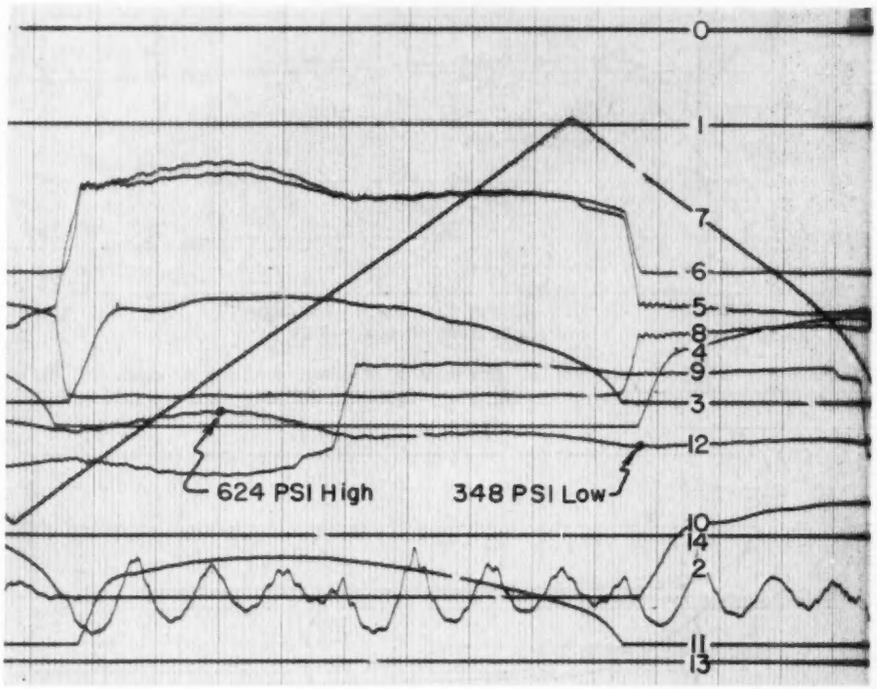


FIGURE 39—The dampener efficiency is low when the operating pressure is near or lower than the charged pressure.

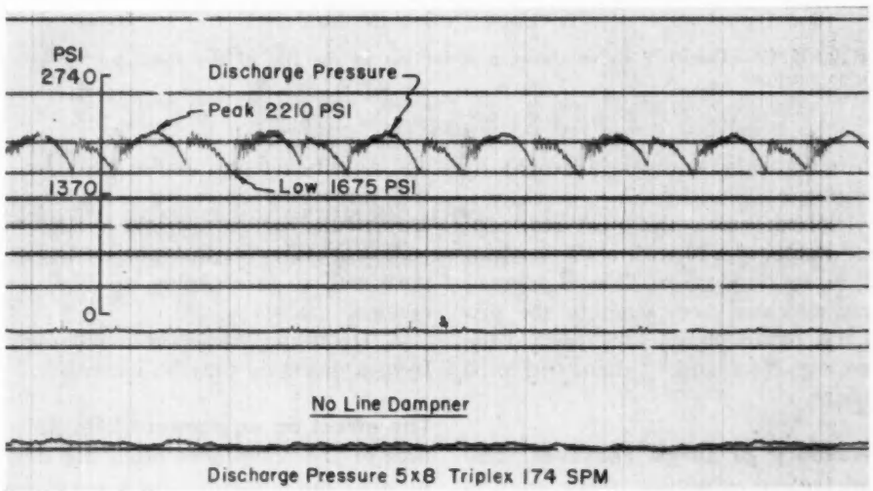


FIGURE 40a—Normal surges are observed without a dampener on the discharge line of a triplex plunger.

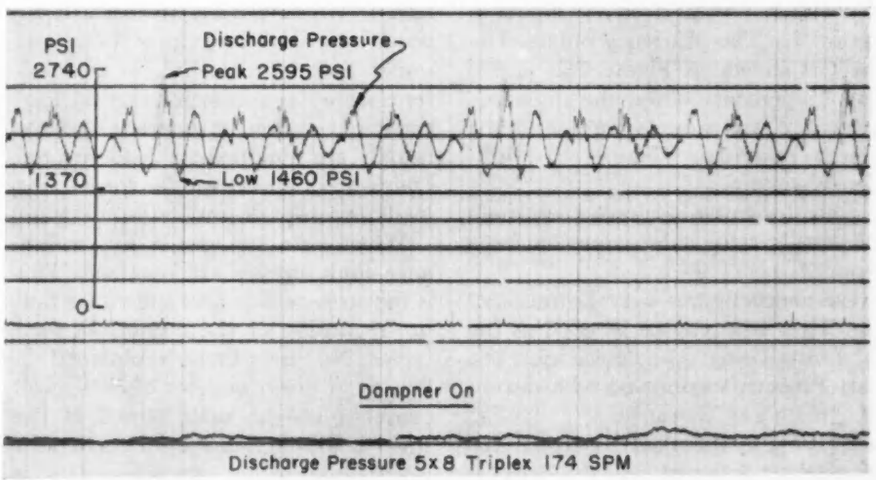


FIGURE 40b—Dampeners placed at poor locations will increase pressure surges.

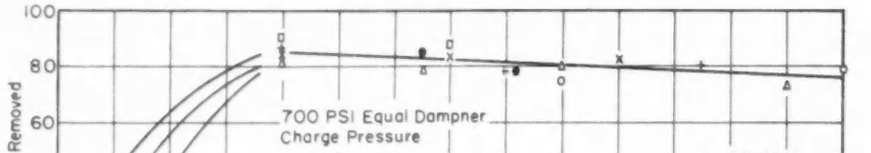


FIGURE 41—Typical efficiency is shown of a common commercial dampener in a good installation.

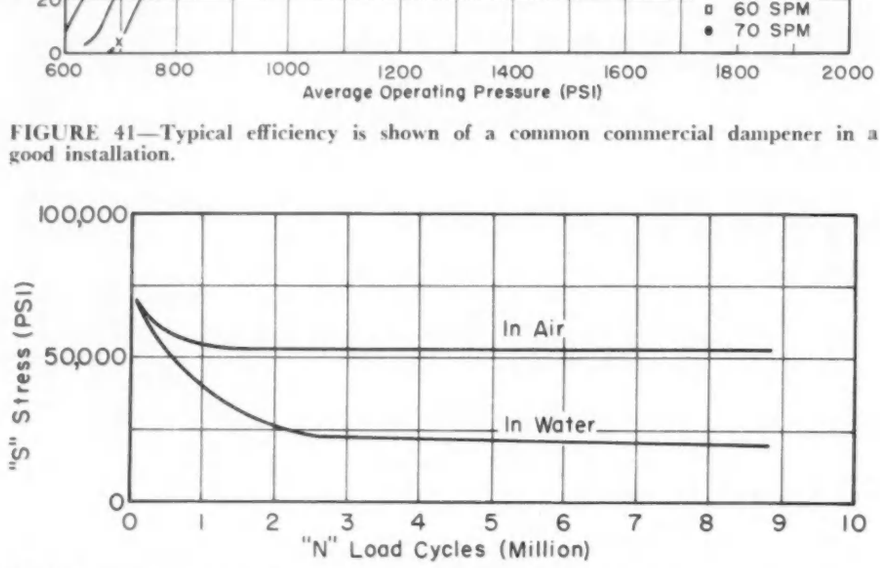


FIGURE 42—The S-N curve shows a reduction in the life of the steel due to corrosion fatigue.

showed only a small amount of surging.

In both cases, the gage read approximately 1,880 with a 100 psi plus or minus variation. The dampener was relocated very close to the discharge of the pump. This reduced the surging effect and eliminated pipe failure.

Efficiency of surge removal. The ratio of the amplitude of the surge in discharge pressure with and without the dampening device often is referred to as efficiency. The efficiency of a typical commercial device is shown in Figure 41. The efficiency obtained in the test shown in Figure 38a and b was 82 percent. When the discharge pressure was nearly equal to the charge pressure (Figure 40), efficiency was low.

This device would have been more efficient had the charge pressure been reduced.

Efficiency figures may be misleading. They will only be as good as the total installation. The device must be:

1. Properly engineered with respect to volume and pressures.

2. Properly installed to obtain the capabilities designed into the device.

If the above requirements are met and an efficient installation obtained, two important operating advantages may result:

1. The life of the pump, pump parts and surface piping may be increased.

2. Hydraulic horsepower obtained from a given rig may be increased.

The effect on equipment life. Failures of the equipment often are due to wear but also may be a result of corrosion fatigue. Metal parts exposed to a liquid such as water, oil or drilling mud may suffer from corrosion fatigue where repetitious loading occurs. Several tests have been run under such conditions to establish representative curves for certain load capacities on given materials. Data usually are obtained for load reversal (push-pull), but is similar for varying loads (push-push and pull-pull).

When tests are run in air, endurance limit stresses are obtained. This is the stress which does not cause failure regardless of the number of load cycles. No such limit is obtained in liquids. A given number of cycles will cause failure at some stress. If the stress is lower, failure will occur at a greater number of cycles. This is shown for Figure 42.

Since there are so many variables in materials and configuration, we can only indicate the effect one could expect from the use of a dampener. If the variation in stress is reduced by reducing the pressure surge amplitude, an increase will be gained in the number of cycles before failure occurs. This is accomplished by a dampener and accounts for much of its success.

In reviewing Figure 38a, caution must be given in estimating the increased life because of the increase in frequency of pulsations. In these tests, the fluctuations occur about four times as often with the dampener as without it. Therefore, stress fluctuation must be less to receive equal life. A device that produces a smooth discharge pressure with no pulsations, when measured with highly responsive equipment, would give even better equipment life than now can be obtained.

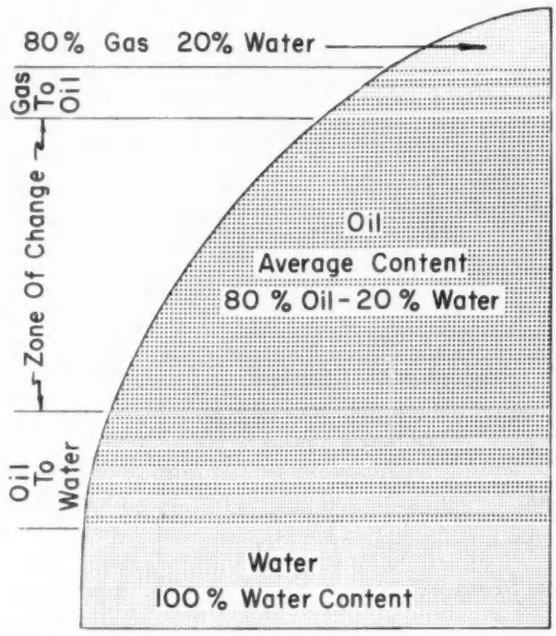
How does a dampener increase hydraulic horsepower? The engine-pump combination is more effective at delivering its rated power because of the steady operation with the dampener.

The engine is set to deliver a certain power to the pump. When a dampener is not used, the power will be based on the peak pressure. However, the hydraulic horsepower output will be based on the average pressure and flow. If a dampener then is placed on the line, the pressure will smooth out to a mean reading.

The maximum engine power required then will be calculated for the average pressure instead of the peak that was previously required. Since the engine is rated to handle the peaks, the dampened pressure can be raised to the peak, and the hydraulic horsepower available is based on the peak pressure and the same flow rather than the average. Since in Figure 38 the peak pressure is about 8 percent above average, an increase in hydraulic horsepower of 8 percent could be obtained and transmitted to the hydraulic system for more efficient drilling.

This condition also was indicated in the laboratory (using a dampener on the discharge line) by the higher average pressure that were attained before shearing the relief valve pin.

TO BE CONTINUED



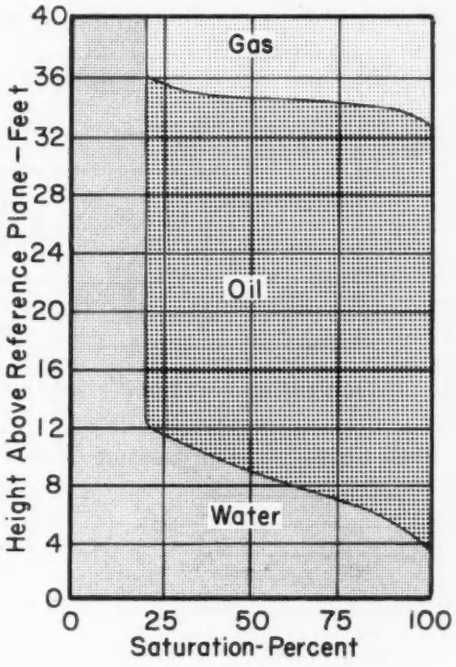


FIGURE 1—Schematic drawing of a typical water-drive sand reservoir with three phases present—gas, oil and water[3]—is shown with the fluid saturation in each phase and transition zone. This is the reservoir fluid distribution before the drill penetrates the sand.

Here's how to use . . .

Radioactivity logs for gas location

Recently developed techniques permit accurate location of LPG-brine interfaces, points of gas entry into a bore hole and potentially productive gas zones

By Dan H. McLendon
Division Sales Engineer and Geologist
The Lane-Wells Company, Dallas

WHEN it is advantageous to locate gas in a drill hole, the radioactivity log has yet to be surpassed for reliability and ease of interpretation. In some cases, it fails to give the desired result due to conditions of deep fluid invasion, etc. On the whole, however, the radioactivity log is recognized as the best gas log available. Improved instrumentation, the ability to log wells under flowing conditions and a better understanding of subsurface conditions are constantly improving success ratios.

The gamma ray log is a measure of the natural radiation of formations. All earth formations contain radioactive elements, some more than others. There are three families of elements which are radioactive—the uranium series, the actino-uranium series and the thorium series. An atom of uranium will be at one stage ionium.

ACKNOWLEDGMENT
This article is based on a paper presented at the Gas Technology Symposium, sponsored by the American Institute of Mining, Metallurgical and Petroleum Engineers in Shreveport, La., in April, 1958.

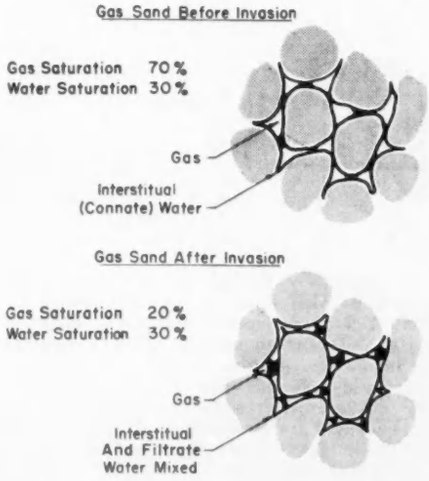


FIGURE 2 (left)—During penetration by the bit, filtration takes place and all mobile gas is forced back into the formation. Only residual gas remains at the formation face. An original gas saturation of 70 percent may be reduced to 20 percent after invasion by drilling fluid filtrates. This condition exists after well is drilled and is ready for logging. Clearly, the hydrogen saturation is altered by infiltration to a great or less depth, depending on the filter cake building properties of the mud, filtration time and porosity of formation. If depth of filtrate invasion equals or exceeds depth of investigation of the neutron instrument, the presence of a gas probably would remain undetected from the log alone.

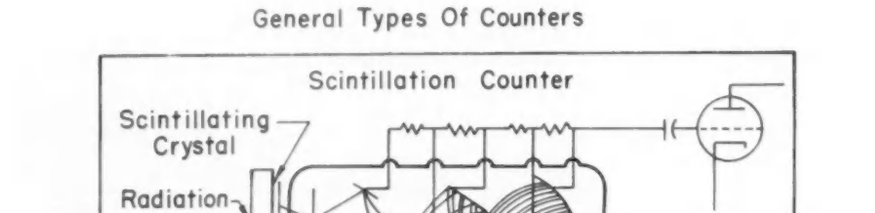


FIGURE 3—Radioactivity detectors fall into three general categories—ionization chamber, Geiger-Muller and proportional counters and scintillation counters. The top diagram is of the scintillation counter type in which light flashes of the scintillating crystal are amplified by the photo multiplier tube. This type of detector is the most efficient of any in use at the present time. The second diagram is an ionization chamber which depends on the degree of ionization of gas to determine the level of activity. High pressure gas and low electrical potential across the gas is characteristic of this type instrument. The proportional counter or Geiger-Muller counter uses low pressure gas and extremely high potential across the gas to detect the presence of radiation. This detector completely discharges with a small degree of ionization of the gas. Efficiency wise, these detectors rank as follows: scintillation counter, first; Geiger-Muller, second; and ionization chamber, third.

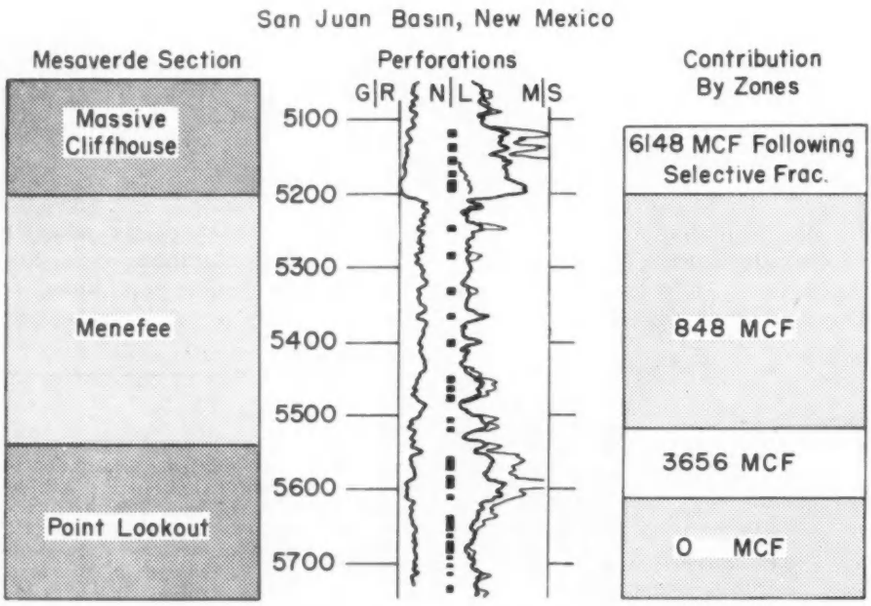


FIGURE 4—In the San Juan Basin, wells are normally drilled in with gas as the circulating medium, due to lost circulation problems. This shows a typical multispaced log of the Mesaverde section with perforations indicated. Notice that there are two curves on the neutron side. These are recorded at different neutron source—to detector spacings. The anomalies are thought to be due to normal response at different spacings. The fact remains that core and all other information indicates that the best producing sections are those in which the long (or dotted) curve extends a greater distance to the right than the short curve. These sections are perforated for production. At the bottom, when the curves come together, there is very little gas present and fluid saturation approaches 100 percent. The test data shown bears this conclusion.

then radium, then radon, etc., and end the progresison as non-radioactive lead. At almost every stage of this progression, some form of radiation is given off.

The radiation will be an alpha particle, a beta particle or gamma ray. Although each moves with very high velocity, a thin sheet of bond paper is sufficient to stop an alpha particle. The beta particle has more energy than the alpha; however, several sheets of cardboard provide a successful shield from the radiation of betas. Gamma rays have the ability to penetrate 12 inches of steel or 8 inches of lead. From this, it is easily seen that only gamma rays may be detected with the instruments now in use since the instrument wall is sufficiently thick to shield out alpha and beta particles.

Furthermore, the gamma ray has such great penetrating qualities that a well may be cased with concentric pump liners and a formation gamma ray log still can be obtained. The neutron is little more affected by casing so neutron logs may be obtained in a well cased with heavy pipe.

Conveniently, all sedimentary formations contain assemblages of these radioactive elements. If the amount of radioactivity present can be recorded depthwise, it should be possible to correlate logs from well to well if radioactive properties of the formations remain constant. This is done with the gamma ray log.

A neutron, as run today, is a hydrogen log. This means that it is more responsive to hydrogen than to any other element. The formation is bombarded with neutrons from a source affixed to the bottom of the instrument. Since a neutron is approximately the same size as a hydrogen atom, the hydrogen is more effective at slowing down the neutron than other atoms encountered. When slowed down sufficiently, the neutron can be captured by any atom encountered and the energy rebalance of the capturing atom usually causes a fast gamma ray to be emitted. A detector placed a specific distance above the source will record the relative hydro-

gen saturation of the formation logged by recording the intensity of fast gamma rays.

There are two types of neutron instruments generally in use, the neutron-gamma and the neutron-neutron. In the first case, neutrons bombard the formation, and fast gamma rays are detected; in the second, neutrons bombard the formation, and slow neutrons are detected. In the environment surrounding a detector, the concentration of fast gamma rays will approximate that of slow neutrons because fast gamma rays originate at the point where the neutrons reach slow, or thermal, state. Both types of logs are interpreted in the same manner.

The presence of casing alters neutron response but amounts to only a shift on the log. Practically all combination gamma-neutron logs in sand country are run in cased holes. The radioactivity log is the only log capable of recording lithology and formation fluids behind the pipe. To differentiate oil from water still defies research, but in a majority of cases, gas can be differentiated from fluid behind the pipe.

Figures 4 through 12 are examples of radio-activity logs which have been used to aid in completing gas wells.

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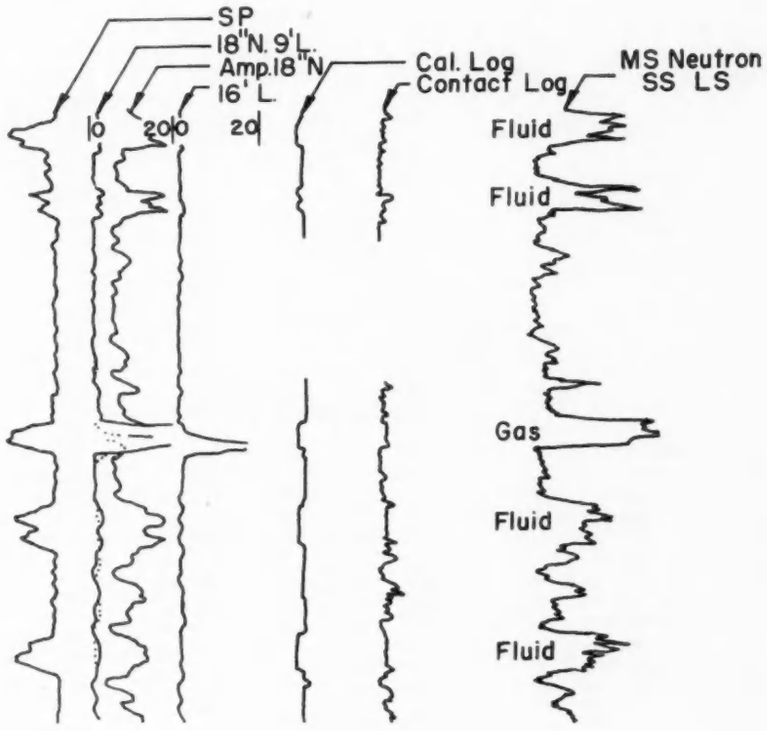

FIGURE 5 (top)—In South Texas, this multispaced log was run for an independent. As opposed to the technique of recording the multispaced curves in Northwest New Mexico, this log was recorded with gas intensity of short curve equal in magnitude to gas intensity of the long curve. These intensities may be manipulated at the surface. In this case, all gas-bearing sections have equal intensity (or coincide); all fluid-bearing sections show less intensity on the long curve than on the short curve. Regardless of the mechanics of recording, results are the same. Gas-bearing formations give greater neutron response than those carrying water or oil.

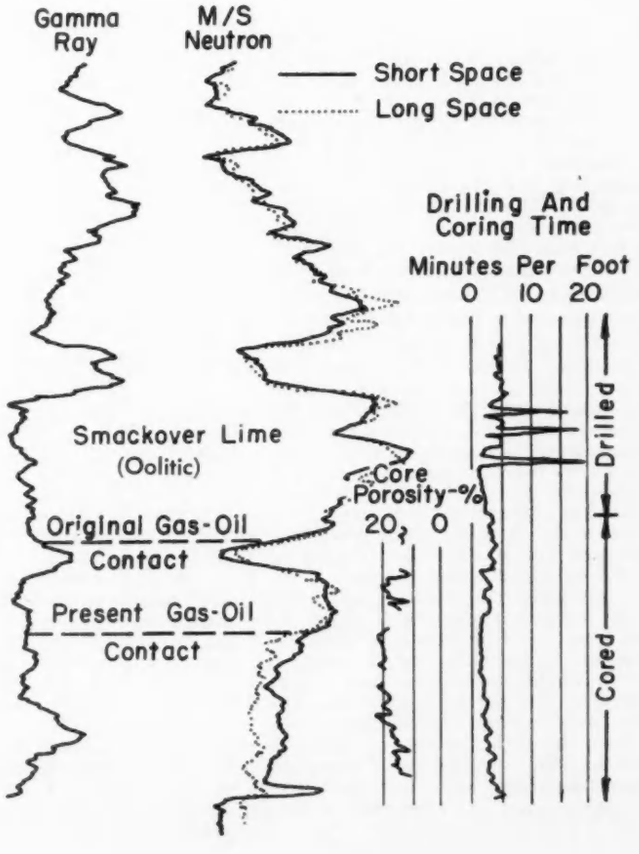

FIGURE 6—In the Magnolia field, Arkansas, the gas-oil contact behind the pipe has been detected, using multispaced neutron. These wells were logged with a one-and-three-fourths inch O.D. combination instrument, through tubing and casing. It was necessary to lubricate in against 700 psi on the tree. Consistent porosity is noticed on porosity graph across the gas-oil contact. Also, coring time shows little change at the contact. The method of recording these curves is similar to that used on South Texas log. This technique of locating gas-oil contacts is being studied for volumetric calculations. Thus far, it has proved to be the most economical. Results are reasonable when compared with material balance calculations, water injection data, etc.

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Gas bearing or dense zones show increased neutron intensity ...

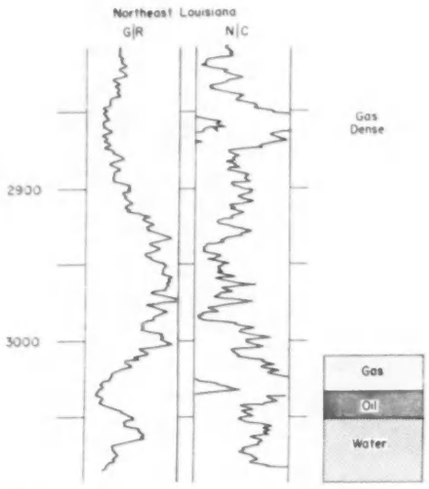


FIGURE 7 (above)—This log, in northeast Louisiana, shows a gas-oil contact at 3,036 feet—tests proved this. In this case, a single curve neutron was used. Also, this log surprisingly shows an oil-water contact. The section at 2,800 feet, showing high neutron intensity, may be gas-bearing, porous sand or dense—there is not sufficient information to determine which one. An open hole electric log, contact log or drilling time log would provide the needed information for interpretation of this zone.

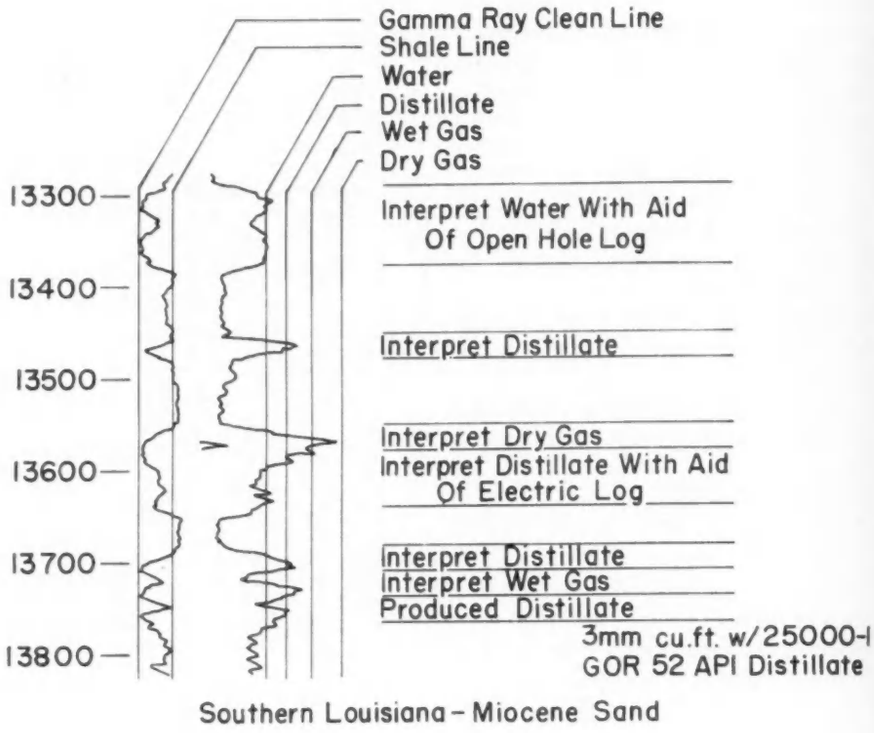


FIGURE 8 (top right)—This log was run to a depth below 13,700 feet in South Louisiana. Gas, distillate and water are shown. This is a Miocene sand with high permeability; porosity ranges from 30 to 35 percent. The section at 13,350 feet is water bearing. At 13,570 feet, there is a sand carrying dry gas—grading into distillate at 13,588 feet. The lower portion of this sand also carries distillate, but porosity is somewhat lower. At 13,690 feet, there is a wet gas sand with two large shale breaks down to 13,750 feet, where the well was completed as a distillate well. Perforations were from 13,750 to 13,770 feet. The well produced 3,000 MCF of gas, with 4500 psi tubing pressure through a small choke. Gas-oil ratio was 25,000-1 and distillate gravity was 52. By comparing the neutron intensity for sands of equal cleanliness, water, distillate, wet gas and dry gas intensities may be drawn in. In shaly sand sections, gamma ray correction necessary to make the sand clean, should be determined. The neutron then should be corrected before applying the water, distillate, etc. scale. For example, at 13,610 feet, the gamma ray is three chart divisions from the shale line and three divisions short of the clean line. To make it clean, it would need three more chart divisions, or 100 percent correction. The neutron reads seven-and-a-half chart divisions from the shale line. When corrected by 100 percent, it would read 15 and fall between "distillate" and "wet gas." Untested sands may be evaluated in this manner.

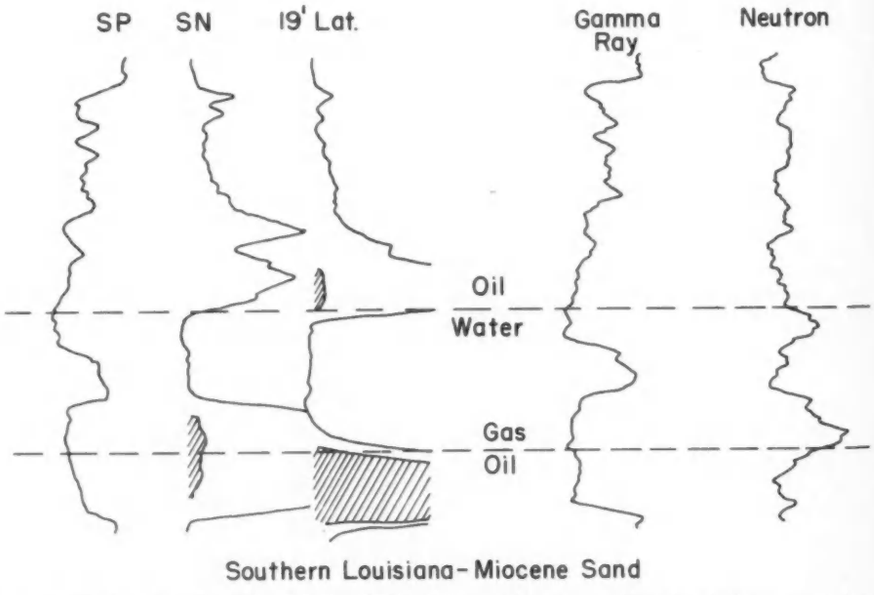


FIGURE 9 (above)—Also in South Louisiana, this figure shows a Miocene section with electric log and combination radioactivity log. Of note is the high resistivity on the electric log in the lower section containing gas and oil. The neutron in this section picks the gas-oil contact by dropping back at the contact. Test data and side wall samples substantiate this as a valid gas-oil contact. In the upper sand, no gas is present and the neutron is observed to be at a low intensity. This is an example of the oil-water contact shown by the neutron—at the contact, the neutron is higher in the water phase than in the oil phase. In all instances, the neutron intensity is greater for gas-bearing sections than for those carrying fluid. This single fact, if kept in mind, can be considered most important when interpreting logs for locating gas behind casing. Since a dense lime or anhydrite exhibits high neutron intensity also, care must be taken to prevent erroneously interpreting the dense zone as a porous zone carrying gas. A drilling-time log, contact-type log or electric log will help in this respect. Due to low porosity in the dense section (even though 100 percent fluid saturated), the neutron will indicate approximately the same hydrogen saturation as a high porosity gas-bearing section.

FIGURE 10 (below)—A specialized application of radioactivity logging has been developed for determining the fluid—LPG level in underground cavities dissolved in shallow penetration salt plugs. A one-and-three-fourths-inch O.D. instrument is used. A radium source emits gamma rays. Scattering of gamma rays is a function of the density of the environment surrounding the instrument. Since brine is more dense than LPG, gamma rays lose their energy faster due to the presence of more and larger atoms. By recording at the proper source spacing, the gamma ray intensity reflects the relative density of the fluids logged. When intensity is highest, LPG is the environment; where lowest, the environment is brine. The instrument is lubricated into the tubing at well head to obtain the log shown on left of diagram. The lower excursion to the left is the result of entering the tubing string from the open cavity. The next excursion above this is the gas-brine interface. The upper excursion to the left is due to the effect of entering the casing string. By injecting or producing gas and relogging, interface changes are determined. Thus, it is possible to calculate capacity of the entire cavity at various levels, so the volume of gas in storage may be determined at any time by a subsequent log. Since the method was introduced several years ago, more than 150 logs have been run. The positive results obtained and the ease of interpretation make this logging procedure popular among those companies which store LPG in salt solution cavities.

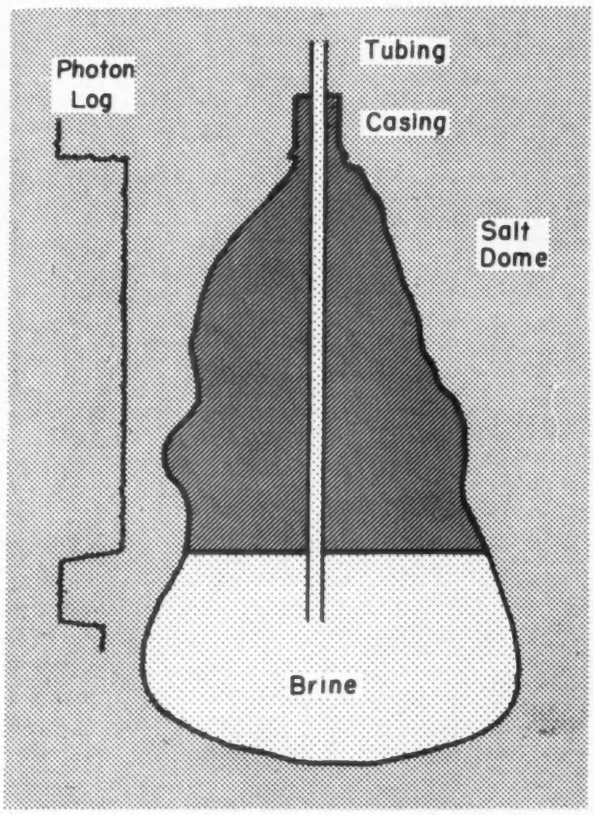
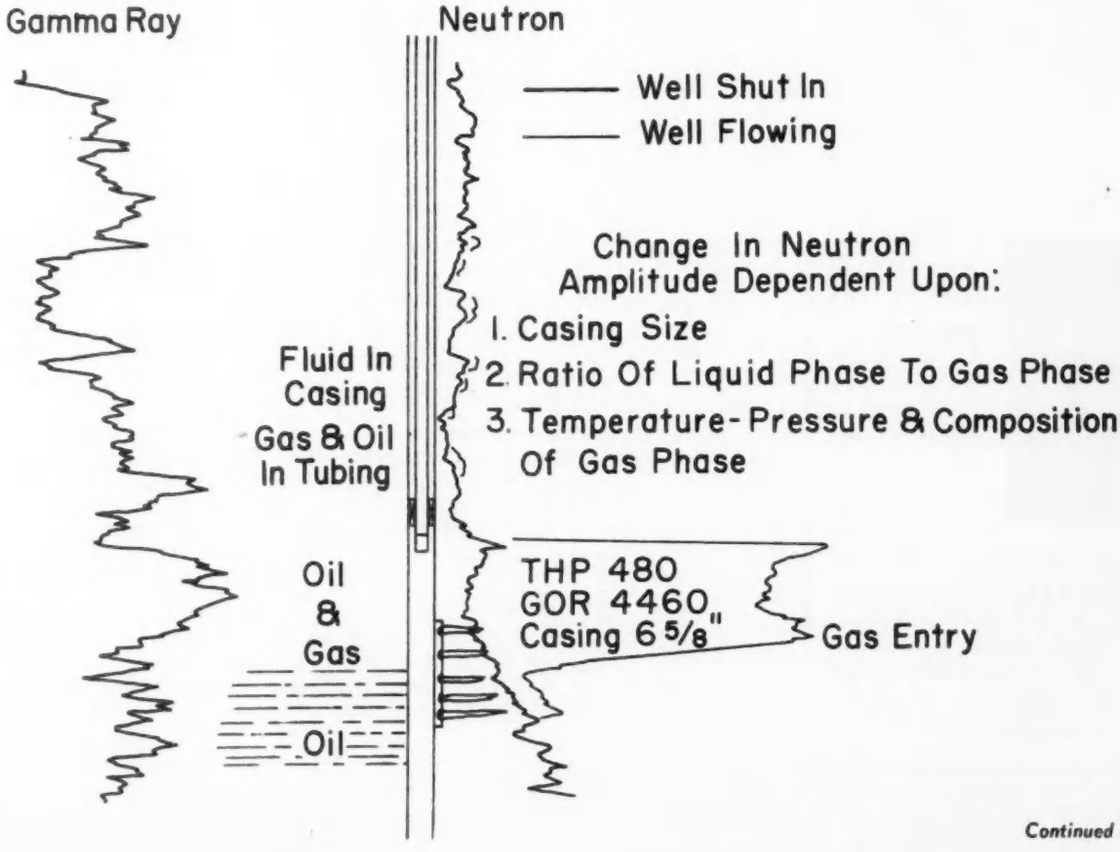


FIGURE 11 (below)—A technique of determining gas entry points in a bore hole was developed about a year ago in Venezuela.[4] The problem was to determine gas entry points, squeeze the well and reperforate in the oil zone to improve the GOR. To date, more than 60 logs of this type have been run. This is referred to as the "flowing neutron." The detector in use is a one-and-three-fourths-inch combination gamma ray neutron tool—since the log is run through tubing. While the well is flowing, the instrument is lubricated in the hole and the log run. After recording the flowing log (and without removing the instrument from the hole), the well is shut in and allowed to stabilize—and an additional log rerun. The gas and oil mixture within the bore hole is regarded as being responsible for log response. At the bottom of the perforated interval, the two neutrons depart. As long as departure remains constant, the section is interpreted as productive of oil. Thirty feet higher, the flowing neutron departs to the right and from this point to the sand top—the section is gas productive. Entire section was squeezed and reperforated lower to make a low GOR completion. Below points of fluid or gas entry, log repeats itself. In the oil producing section, a small amount of solution gas pops out of solution to aerate the oil column—this influences the neutron. In the gas-producing section, only gas is entering and a great degree of aeration takes place. The casing size, ratio of liquid phase to gas phase and conditions of temperature, pressure and composition of gas phase control the amount of departure between flowing and shut-in logs.



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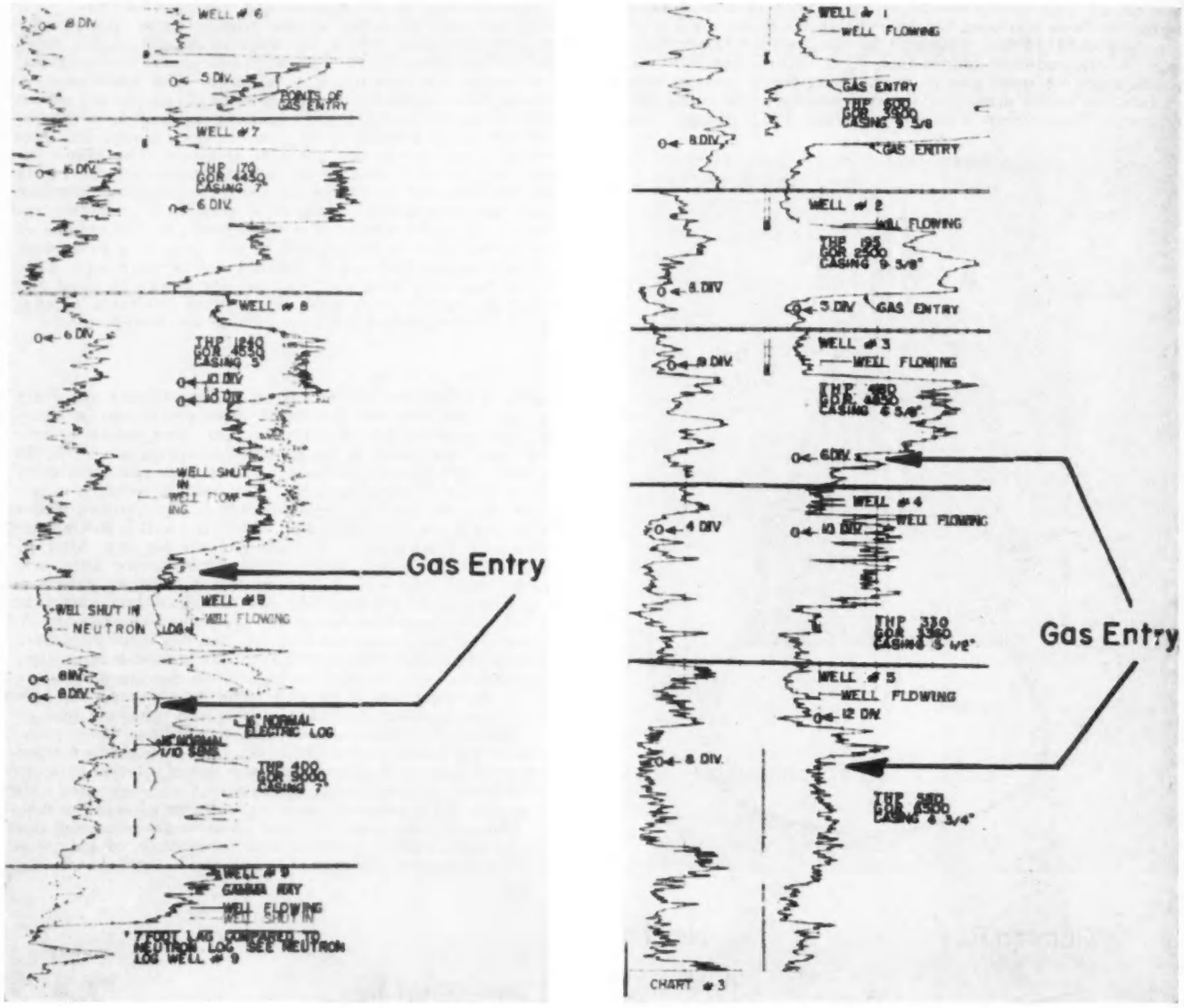


FIGURE 12—Well No. 1 and well No. 6 show more than one point of gas entry. The same logging method used in Figure 11 was also used here. The following rig site procedures are required to successfully log a flowing well:

1. Allow the well to flow until a normal GOR is obtained before commencing logging operations.
2. Rig up a thru-tubing high pressure lubricator.
3. Log thru-tubing with a one-and-three-fourths-inch gamma ray-neutron instrument. Sinker bars may be required to enable the instrument to move against flowing pressure. With a five-sixteenths-inch line, wells with flowing pressures of up to 1,100 pounds can be successfully logged.
4. Shut the well in.
5. Re-run the log.

From the beginning, the method has been successful. A properly interpreted flowing neutron log can locate the points of gas entry in a flowing well almost 100 percent of the time—and with an unusual degree of efficiency.

—The End

About the Author

Dan H. McLendon received a B.S. degree in geological engineering from Texas A&M College in 1939. He joined Lane-Wells in 1940. He served in the armed forces from May, 1941, to September, 1945. Following military service he rejoined Lane-Wells and is presently division sales engineer in Dallas.

Here's latest information on . . .

Oil prospects in the Bahamas

Strong to gentle folding plus possible salt domes and strat traps increase potential of the Bahamas' Evaporite basin

By Harry Wassall, President, and **Howard Dalton,** Geologist
Harry Wassall and Associates, Havana

OIL POSSIBILITIES of the Bahamas are similar to those of Southern Florida and Northern Cuba. Best chances for production appear to be in porous dolomites or limestones similar to those found in the Sunniland field of Florida, and in Shell Oil Company's Cayo Coco 2 in Cuba. Structures probably will vary from strong simple folds just north of Cuba, to gentle folds approaching Florida. Also salt domes could be present since salt structures found on the north coast of Cuba suggest that a salt section underlies the oldest rocks drilled in the deepest parts of the Evaporite Basin. In the northeastern Bahamas, it is possible that up dip changes in lithology (towards a more clastic facies) may provide stratigraphic traps.

The section consists of evaporites interbedded with dolomitized marine limestones having a high carbonaceous content and zones of good secondary porosity. Most of the carbonates indicate oil cuts when crushed with solvents and may be considered source rocks. Other types of source rocks may exist below undrilled sections. Thick sections of anhydrite in parts of the basin provide ideal cap rocks. Other types of cap rocks also may exist in the undrilled areas.

The regional geology of the Evaporite Basin indicates that the Bahama Islands and surrounding shallow waters are underlain by sediments more than 15,000 feet thick in most areas.

STRATIGRAPHY OF BASIN

The stratigraphy of the Bahamas proper is known only from Superior Oil Company's Andros Island 1, the only test completed so far. However, it is expected that the section in other areas will be similar to that found in the subsurface of Florida and Cuba. The most important part of the section for oil exploration is the Paleocene, Cretaceous and Jurassic.

Following is a brief description of the regional stratigraphy of the basin:

Pennsylvanian (?) and older—South Florida—unknown thickness. The only rocks older than Jurassic are found in the central Florida peninsula where a land mass once existed forming the northern boundary of the basin. Wells in central Florida have bottomed in a variety of igneous, metamorphic and sedimentary rocks believed to range in age from Pre-Cambrian to possible Pennsylvanian.

Upper Jurassic—South Florida, Cuba, Bahamas, unknown thickness. Some paleontologists consider the lower part of the anhydrites and dolomite in the deeper wells in Florida (along with the salt stringers found in that part of the section) to be Upper Jurassic. In Cuba, Upper Jurassic dolomites have been identified, and it is believed the massive salts found in subsurface dome-like structures on the north coast may be Upper Jurassic or older. In the Bahamas, the Jurassic was not encountered in the Andros Island 1.

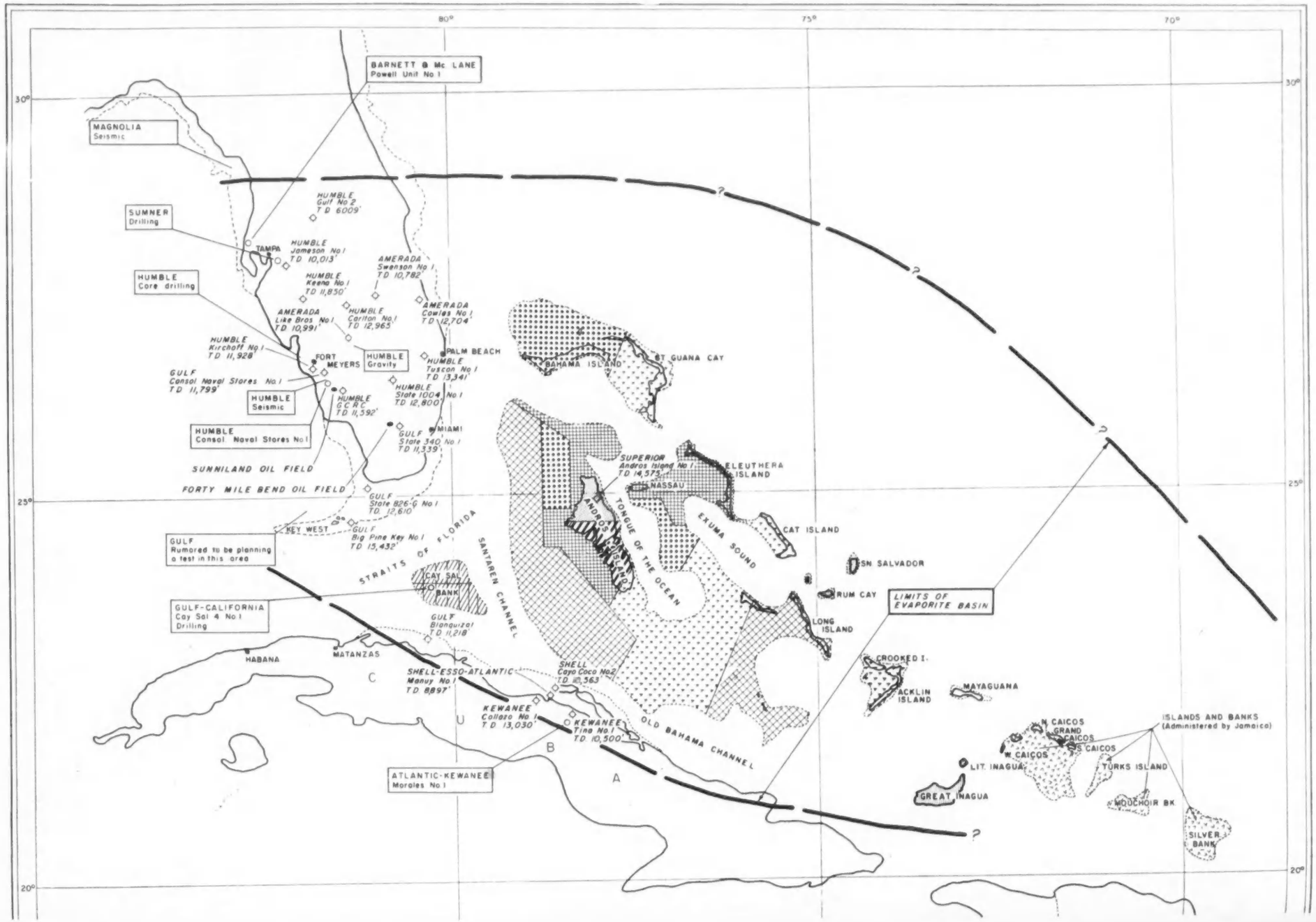
Cretaceous—South Florida — 2,500 to 10,000 feet: Bahamas—6,000 + feet. In Florida, the Cretaceous section consists of anhydrite and dolomite with some limestone. The Cuban Cretaceous is similar to that of Florida except for the occurrence of some calcareous shales. Crystalline and dense dolomite with some late primary dolomite make up the Cretaceous of the Bahamas. (In Andros Island 1 this section was found overlying 700 feet of limestone with cavernous porosity at the top and base.)

Tertiary: South Florida—4,250 feet —thinning northward. The Tertiary of southern Florida is composed of gypsum, anhydrite and limestone with sand, gravel and clay near the top of the section. In the Bahamas, there is over 2,000 feet of anhydrite, coquina, chalk and dolomite.

STRUCTURE OF THE BASIN

The Pennsylvanian and older rocks found at the bottom of wells in the Central Peninsula of Florida represent an old land mass which formed a northern barrier to the evaporite basin and which was onlapped transgressively by Cretaceous beds. The top of the upper Cretaceous and younger beds continue northward, covering the old high, but there is a change in facies from evaporites and carbonates to mainly clastics. South of the Central Peninsula this old unconformity surface plunges into the basin and has not been found in Cuba or the Bahamas, although it is believed to be present northeast of the Bahamas. The exact southern limits of the evaporite basin are not known because it is hidden under a northward thrust sheet. However, in Cuba the thrusts are composed of deep marine limestones of Cretaceous and Jurassic age, indicating a gradual facies change southward to a non-evaporite section. For oil exploration purposes, the southern limits may be considered to be the present day front of the overthrust limestone.

Ample subsurface control in Florida shows a high developing in the Cay Sal area. This coincides with reports that an extremely large seismic anomaly has been found there. One regionally low area is indicated west of the Sunniland field in Florida, and another in the Andros Island area. North of Sunniland, a fairly uniform, basinward, regional dip is evident. Seismic and subsurface work in Southern Florida indicates that broad gentle folds are imposed on the overall regional dip as in the case of the Sunniland field. In Cuba, however,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BARNETT & Mc LANE
Powell Unit No 1
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SUMNER
Drilling
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Core drilling
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Gulf No 2
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Jamason No 1
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Gravity
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Tuscon No 1
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GULF
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SUNNILAND OIL FIELD
FORTY MILE BEND OIL FIELD
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State 826-G No 1
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KEY WEST
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Big Pine Key No 1
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GULF
Rumored to be planning
a test in this area
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SANTAREN CHANNEL
CAT SAY
BANK
GULF-CALIFORNIA
Cay Sal 4 No 1
Drilling
GULF
Blanquizal
T D 11,218'
HABANA
MATANZAS
SHELL-ESSO-ATLANTIC
Manuy No 1
T D 8897'
SHELL
Cayo Coco No 2
T D 10,563'
KEWANEE
Collazo No 1
T D 13,030'
KEWANEE
Tina No 1
T D 10,500'
ATLANTIC-KEWANEE
Morales No 1
OLD BAHAMA CHANNEL
BAHAMA ISLAND
GT GUANA CAY
SUPERIOR
Andros Island No 1
T D 14,575'
NASSAU
ELEUTHERA
ISLAND
ANDROS ISLAND
TONGUE OF THE OCEAN
EXUMA SOUND
CAT ISLAND
SN SALVADOR
RUM CAY
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ISLAND
MAYAGUANA
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LIT INAGUA
GREAT INAGUA
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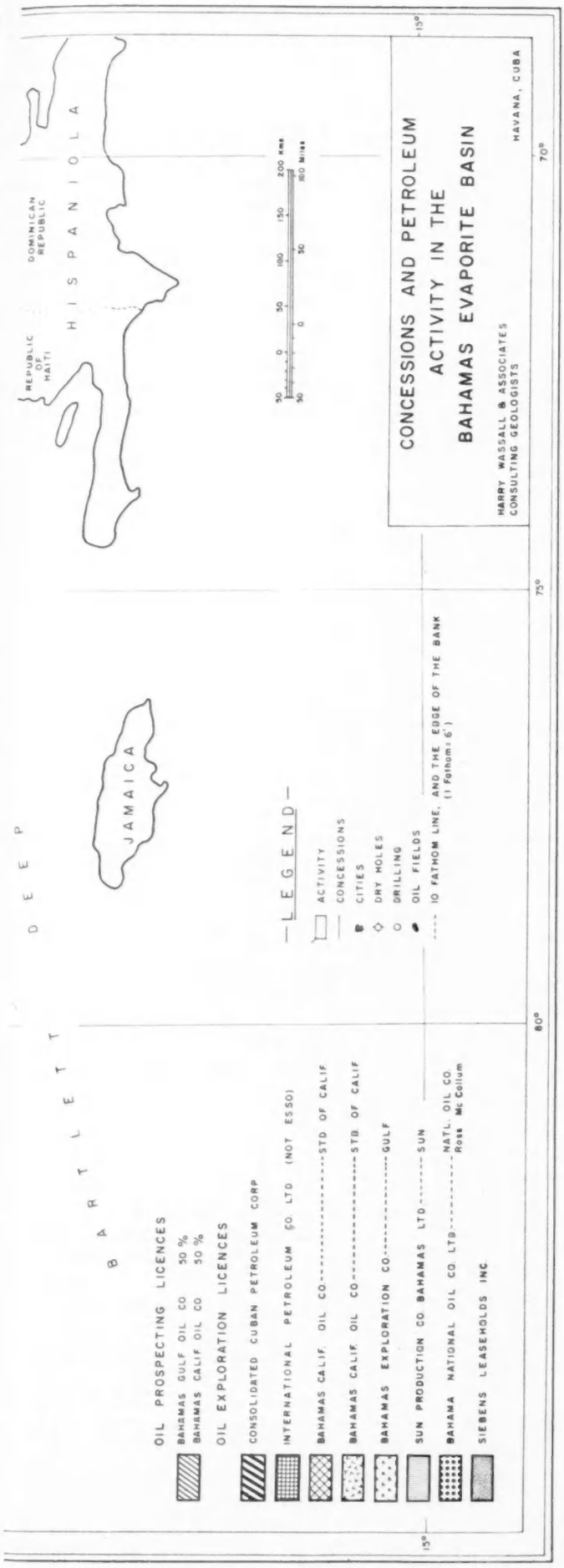

the folding terminates against a complex belt striking northwest. Tests drilled in this zone have disclosed salt structures, overthrusts and dips ranging from 30 degrees to vertical. South of this zone, the evaporite section disappears under the major limestone overthrusts which have been cut by nearly vertical faults, thus adding to the complexity.

In the Bahamas, no definite structural information is available since only two tests have been drilled and the current well is a "tight" hole. It is hoped, however, that a zone of strong but uncomplicated folding exists between the intensely deformed structures in Cuba and the gentle folds in Florida. This would represent a more favorable area for oil accumulation.

BAHAMAS

The Bahama Islands cover a land area of approximately 4,404 square miles, and are adjacent to huge areas of shallow water banks. Water depths in the area range from 10 feet to 30 feet. The high cost of drilling water has discouraged exploration in the area and a second test was not started until March, 1958, when Bahamas Gulf Oil Company and Bahamas California Oil Company began Cay Sal 4 No. 1. This well was located on the basis of a shallow water seismic program which covered most of the Cay Sal Bank and was reported to have yielded good records.

Tests. Superior, Andros Island 1 was drilled to 14,585 feet in 1945, reportedly as a stratigraphic test. The following sections were encountered:

Depth	Feet	
0—	1,950	Oligo-Miocene limestone.
1,950—	6,590	Eocene limestone and dolomite.
6,590—	8,500	Paleocene dolomite.
8,500—	10,150	Upper Cretaceous dolomite.
10,150—	10,660	Upper Cretaceous limestone.
10,660—	14,585	Lower Cretaceous (total depth).

Anhydrite was missing from the section, but could be present within a few miles of the test as in the subsurface of Cuba.

California-Gulf, Cay Sal 4 No. 1 was spudded on March 23, 1958. It is located approximately 131 miles due south of Miami on Cay Sal Bank in the southeastern Bahamas. After setting 7-inch casing at 15,131 feet, the well now is drilling below 15,328 feet on a projected 16,000 foot test. Objectives are the porous dolomitized limestones intercalated in anhydrite beds found in the producing section in Southern Florida. The well is a tight hole and formation data are not being released.

Review of oil exploration. Current interest in the Bahamas Evaporite Basin is centered on Gulf-California's Cay Sal 4 No. 1 well. Exploration was triggered

FIGURE 1—As shown on the map, the following companies hold concessions in the Bahama Islands:

Oil Prospecting Licenses: (Carrying obligations to drill)
Gulf Oil Corporation and Standard of California (held jointly) 1,234,328 acres.

Oil Exploration Licenses: (Carrying obligations to do geophysical or geological work)

Gulf Oil Corporation	9,393,416 acres
Standard of California	9,143,000 acres
Standard of California (Jamaica Administrated)	2,865,011 acres
National Oil Company	5,186,560 acres
Sun Oil Company	675,840 acres
International Petroleum Company (No relation to Esso)	4,291,?00 acres
Consolidated Cuban Petroleum Corporation	960,000 acres
Siebens Leaseholds, Ltd.	842,800 acres

in this area with the discovery of the Sunniland field in Southern Florida in 1943, which proved commercial oil from a Cretaceous-Jurassic evaporite basin. In 1945, La Estrella et al's, Cayo Coco 1 in northern Cuba found 10,563 feet of correlative section. During the same year, Superior Oil Company's Andros Island 1 (the first well in the Bahamas) also found 14,500 feet of correlative carbonates. These two tests proved that the basin extends from the Ocala uplift in Florida to the gypsum outcrops on the north coast of Cuba including the Bahamas Islands and Banks.

While the Bahamas appear to offer the most favorable area for oil exploration direct information is limited to only a few details on one test. Due to this lack of data, it is necessary to examine the information available from other parts of the basin in southern Florida and northern Cuba.

SOUTHERN FLORIDA

The Sunniland discovery started an exploration boom in the basin that was concentrated mainly in Southern Florida because of the ease of operation on land and since it was within the United States. Over 20 deep wildcats have been drilled on the lower Florida Peninsula, mostly on seismic information. Several have recovered free oil, with the only new discovery at Forty-Mile Bend field, which was opened in 1954. However, this proved non-commercial. It is believed that discouraging results are due to poor seismic records. Nevertheless, potentials are sufficient to justify continued operation by the principal leaseholders.

The fields and wells discussed below show the type of production and oil shows encountered:

• **Sunniland field (30 miles south of Fort Meyers, Fla.).** Discovered in 1943 on a seismic high, this field is currently producing about 1300 barrels of 22-25 gravity oil per day from 11 pumping wells. Total production to 1957 was over five million barrels. The pay zone consists of 40 feet of porous, lower Cretaceous limestones at 11,500 feet. The field has about 200 feet of structural closure.

• **Forty-Mile Bend field (about 40 miles west of Miami).** This field was discovered in 1954, by Gulf Oil Corporation et al's Wiseheart, State of Florida No. 1. The pay zone is a porous limestone at 11,322-339 feet. Initial production was 76 barrels of 20 gravity oil and 96 barrels of salt water per day. A second well on the same structure resulted in a small producer, but went to salt water shortly after completion. Total production of the field was only 32,348 barrels before being abandoned in 1956.

• **Humble Oil & Refining Company—Kirchoff 1 (south of Fort Meyers, Fla.).** A drillstem test at 11,819-928 feet recovered 75 feet of 28 gravity oil and 225 feet of oil and mud. Acid treatment failed to establish production and the hole was abandoned in 1953.

• **Gulf Consolidated, Naval Stores 1 (about 10 miles southwest of Fort Meyers, Fla.).** A drillstem test at 11,748-799 feet (tool open 23½ hours) recovered 40 feet of 28 gravity oil and 145 feet of oil and gas cut mud. The well was abandoned in 1953. This test was about 11 miles east of Humble's No. 1 well.

Current activity. As of December 1, 1958, exploration activity in southern Florida was as follows:

1. **Sumner Oil Company**—This concern currently is drilling below 1,760 feet on a cable tool test. A string of 9⅝-inch casing was set to 1,250 feet and plans are to drill to 6,000 feet.

2. **Humble Consolidated Naval Stores 1**—An electric log has been run to 11,809 feet, total depth. The test will probably be abandoned since the objective, the Sunniland formation, was dry. The test was cored at 11,707-19 feet and at 11,719-809 feet. A drillstem test on the lower interval yielded some oil cut mud but was not considered significant.

3. **Barnett & MacLane, Hancock Power Unit 1**—This well now is shut down at 4,103 feet.

4. **Humble—Continues to core drill in Hendry County** (approximately T4 5s 32e). Also, Humble is operating one seismic crew northwest of the Sunniland field (T4-55-28e) and one gravity crew in the northwest part of Lee County.

6. **Magnolia**—One seismic crew continues to operate offshore west of Levy County.

NORTHERN CUBA

The southern part of the Bahamas Evaporite Basin is covered by the islands and cays of the northern coast of central Cuba. Several wells have been drilled by Gulf, Kewanee Oil Company and a syndicate involving La Estrella (Shell et al), Esso and The Atlantic Refining Company. These wells all found extremely complex structural conditions which indicate this part of the basin was affected by the northward, post-Cretaceous overthrusting in Cuba. In spite of the complications, the same companies continue to be interested in the possibilities. The California Company's major lease block in Cuba is confined almost entirely to this area.

Wildcats. Only five deep wildcats have been drilled in North Central Cuba within the confines of the basin and adjacent to the Bahamas.

La Estrella, et al, Cayo Coco 2 (Cuba). This test was drilled on the basis of seismic work done in 1945, which gave rather poor records because of a hard layer of Miocene limestone near the surface. Zones of porous dolomite with abundant strains of light oil were found at 8,150 feet, 8,350 feet and 8,760-9,000 feet. However, the zones flowed salt water on drillstem tests. Both were found under thick sections of anhydrite.

Gulf, Blanquizal 1. This well was drilled in 1952 on a gravity anomaly which was tested further by a shallow core drill program. A section of lower Cretaceous dolomite with a number of thick dolomite breccias (probably caused by solution of anhydrite) was encountered from 1,680 feet to 11,217 feet, total depth. No significant oil or gas shows were found.

Kewanee, Tina 1. This test was drilled in 1956 on a sharp surface anticline in Tertiary beds at Loma Cunagua. After topping Cretaceous volcanics at 2,970 feet, salt was found from 5,120 feet to 10,526 feet, total depth. Since Cayo Coco 2 bottomed in lowermost Cretaceous to upper Jurassic, it is likely that the age of the salt is upper Jurassic or older. Further drilling in shallower holes indicates the salt structure is more complicated than a typical salt dome.

La Estrella et al, Manuy 1. This test was drilled in 1957-1958 on a large seismic high, about nine miles southwest of Cayo Coco 2. At about 8,500 feet, the well crossed a major thrust fault and found Tertiary limestones under Cretaceous dolomite. For this reason, the test was abandoned at 8,897 feet.

Kewanee-Gulf, Collazo 1. This test, the deepest in Cuba, was drilled to

13,030 feet in 1957-1958 on a surface high at Punta Alegre and found the following section:

Depth	Feet	
—	4,200	Upper Jurassic (?) dolomite and salt below 1,300 feet.
4,200—	8,600	Tertiary limestone.
8,600—	11,500	Cretaceous dolomite.
11,500—	13,030	Upper Jurassic dolomite with traces of anhydrite.

A porous zone with traces of anhydrite below 12,000 feet tested salt water, and a few barrels of black tarry oil were recovered at about 11,400 feet.

Present activity in Northern Cuba consists of a 2,500-foot cable tool test drilling on the salt structure found by Tina 1. This test, Atlantic-Kewanee Morales 1 (Camagüey, north coast of Cuba), has reached 1,115 feet, and is shut down temporarily after setting 10-inch casing.

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About the Authors

Wassall

Dalton

Harry Wassall was a geologist with Shell Oil Company in Wichita Falls, Texas, from 1948-1951 and a geologist with Gulf Oil Corporation in Cuba from 1951-1955. Since 1955 he has been the president of Harry Wassall & Associates, a firm of consulting geologists with offices in Cuba, Argentina, Colombia and Haiti. In addition to consulting work, the company operates sample laboratories in Havana and Caracas, and publishes the "Foreign Scouting Service" which provides detailed coverage of Latin American oil exploration in 22 countries.

Howard Dalton joined Harry Wassall & Associates as a field geologist in Cuba after graduating from Rensselaer Polytechnic Institute in 1956. In 1958 he organized the "Foreign Scouting Service" published by the firm, and is presently in charge of this operation.

Which hoisting system?

Continued from Page 62

and does not show the weight on the derrick.

Calculation of ton miles. The use of ton miles for evaluating the service of a rotary drilling line is not all inclusive since there are so many variables that are impossible to record. However, ton miles is a more accurate method of judging the performance of a line than considering the number of round trips it has made, the number of wells it has serviced or the length of time it has been used.

The calculation of ton miles per round trip depends only on the weight lifted and the distance it is moved. Thus, the ton mile calculation will be the same for either the 6 or 8 lines in the derrick.

Cut-off practice. The number of lines does not affect the calculation of ton miles, but the number of lines does help determine the cutoff practice. If adding more lines gives a higher factor of safety, more ton miles could be expected before cutting off. However, the most important factors to consider in determining a cutoff practice are the height of the derrick and the drum crossover. The points of severe wear in the crown block, in the traveling block and on the drum should be moved. Care must be taken to avoid moving from one point of severe wear to another point of severe wear.

It should be noticed that ton-mile service does not reflect field abuse. When shock loads or other damages are encountered during drilling, allowance must be made for cutoff.

Another important factor in cutoff practice is that visual inspection of the wire rope must take precedence over any predetermined calculations.

Efficiency. Efficiency is the ratio of work output to work input. The efficiency of using either 6 or 8 lines can be determined by using the formula

$$\text{Eff.} = \frac{C^n - 1}{nC^n(C - 1)}$$

When n is the number of times the line passes over a sheave, and C is a constant depending upon the line diameter, the sheave diameter, the bearing diameter, and the coefficient of friction. For 6 lines, Figure 1, n is equal to 7, for 8 lines, Figure 2, n is equal to 9. Not having enough information to calculate C, an assumed value of 1.1 can be used to illustrate the change in efficiency.

$$\text{6 lines, } \frac{(1.1)^7 - 1}{7(1.1)^7\,(1.1 - 1)} = \frac{0.95}{1.36} = 0.7 \text{ or } 70\% \text{ efficient.}$$

$$\text{8 lines, } \frac{(1.1)^9 - 1}{9(1.1)^9\,(1.1 - 1)} = \frac{1.36}{2.12} = 0.64 \text{ or } 64\% \text{ efficient.}$$

From this it can be seen that the more lines used, the less efficient the rig operates.

All of the other factors previously considered lead to the belief that 8 lines would be more desirable in a derrick than 6 lines, but then efficiency is lost in adding more lines. Therefore, a compromise must be made in deciding the number of lines to be used. Safety, rather than efficiency, should be considered first.

Conclusions. There are many different factors to consider in deciding the number of lines to be used on a drilling rig. The most important factor would probably be the design stress of the wire line which is the nominal breaking strength divided by the factor of safety. The shock factor on the derrick to prevent pulling the derrick in is also an important factor to consider. All of the various factors have to be considered for each rig and for each drilling situation, but the pull on the derrick also is very important. It is a fact that increasing the number of lines on a traveling block can decrease the load on the derrick.

The object of this report is to show that an operator of a drilling rig should know what causes failure in the different pieces of equipment he is using. Almost anyone can learn how to operate a rig, but to operate a rig safely requires a thorough understanding of all equipment and its capabilities. Safe operations would reduce not only the number of accidents but also the operating cost of the rig.

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Water can be controlled in air and gas drilling

Part 1: Laboratory equipment and techniques show promise for field application

By Wayne F. Hower, Charles McLaughlin, Joe Ramos and John Land
Halliburton Oil Well Cementing Co.
Duncan, Oklahoma

THE SUBSTITUTION of air or gas for all or a part of the mud used in drilling for hydrocarbons has presented a new and difficult problem to the industry. This problem is the economic control of water that is normally suppressed by the conventional heavier muds.

Many papers have been published during the past few years which have described practically every aspect of "air" drilling. Increased drilling rates and longer bit life have been reported which have contributed to a significant savings in rig time. The resulting economic advantage has varied for different areas and, where no particular troubles were encountered, the savings were phenomenal. As experience was accumulated in this type of drilling, its advantages and disadvantages became more exactly defined. In some instances, the disadvantages outweighed the advantages and caused a cessation of this type of drilling in the particular area. In almost every case, the influx of water to the well bore was the major cause for the return to conventional drilling methods.

All kinds of water production have been encountered and each type presents its own particular problem. The weeping or very low water producing zones provide enough water to wet the cuttings but not enough to flush them out of the hole. These wet solids frequently adhere to each other and, in turn, collect on the sides of the hole or on the drill pipe. The reduction in hole diameter is frequently sufficient to cause sticking of the bit when a round trip is attempted. The periodic injection of water to the air stream can prevent the balling and sticking of cuttings but it must be done at the right intervals to prevent too much build-up on the sides of the hole. Raising and lowering of the drill pipe has been known to shut off such water flows. This is probably due to a mudding off action as the bit passes back and forth over the weeping horizon. Zones that produce moderate flows of water do not present too much of a problem in some areas. If there is enough water produced to keep the hole clean, and, where no water sensitive shales exist, air drilling can be economically continued. However, where several moderate water producing horizons are encountered in one hole, the resulting accumulation of water can overload the air system and cause a return to conventional mud drilling. There are other occasions where a single formation will produce very large quantities of water which will cause a rapid cessation to the use of air as a drilling medium.

The use of surfactants to foam water out of the hole has proved to be very successful in many wells. Hole conditions, such as the presence of water sensitive shales and the quantity of water being produced, as well as the water disposal problem are factors that determine whether such a procedure is technically and economically successful.

The complete control of water in air drilling is much more difficult than in producing wells. The plugging agent must enter the true flow channels that are producing water and shut them off efficiently. The plug, so formed should have the following characteristics:

- Maintain hole size.
- Strong enough to withstand round trips.
- Sufficient for continual beating of the drill pipe.
- Overcome formation pressures.

Many good materials and techniques have been developed for the control of water in oil wells but no one material has been completely successful. In fact, very few of these slurries have been seriously considered in the control of water in air drilling. Conventional cement slurries, the most common sealing material used in the past, will only plug fractures and perforations as cement particles will not enter the true permeability of most formations during a squeeze job.

Laboratory research. A research program was initiated to develop materials and treating techniques to economically control all types of water production. It was deemed advisable to investigate true solutions as the treating agent for water zones where production is from the true permeability of the formation. Such solutions would develop their plugging ability through a chemical reaction which causes the solution to change to a stiff gel or a hard solid after it has been properly placed in the formation. In this way, no decrease in hole size will be developed. Where water is being produced from inherent fractures and/or true permeability, a grouting fluid containing solids would be applicable. A better approach is a slurry with controlled fluid loss where the fluid so lost to the formation will eventually set and cause plugging in

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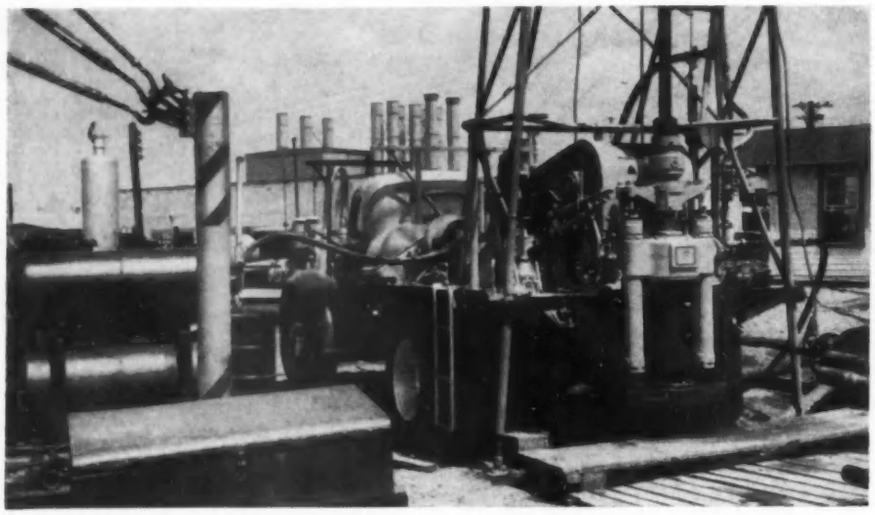


FIGURE 1—A small rig is being used in drilling wells for "pilot plant" placement of water sealing materials.

the small flow channels as well as in the fractures.

As the research program progressed and a better understanding of the problem was accumulated, specifications were developed to describe the preferred treating fluid. They are:

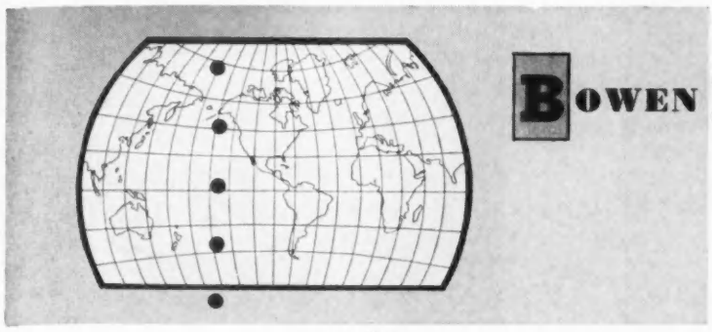
- Low viscosity. As low as possible to aid in the entry of the fluid into all types of flow channels.
- Good viscosity control. A solution that maintains a low viscosity until the setting reaction commences is important. A longer effective placement time in the well is possible with such a fluid.
- Controlled set. Must be reliable in its setting characteristics and must set in a reasonable time.
- The set material must be either a stiff gel or hard solid.
- The entire system must be economical for existing conditions.

Representative cores from many areas were saturated with water and treated with numerous true solutions to determine their plugging action. Generally, almost every material that gave good results which includes both the solutions that polymerized to form stiff gels and those that develop hard sets. In most instances, cores one inch long, that were treated with a low viscosity solution that forms a stiff gel, were able to resist hydraulic pressures up to 2,000 psi.

Research wells drilled to test materials. With several materials available that appeared to be efficient for this use, it was felt that field applications should be performed using the most economical and effective products. However, not too many wells were being air drilled through water bearing formations at that time and, where a joint program was established for the treatment, the water bearing zone frequently turned out to be dry. The above situations, plus the lack of controlled conditions in most instances, never permitted this phase of research to get underway. To hasten the program, the small rotary rig shown in Figure 1 was purchased and rigged up at the Research Center. The rig was adapted to air drilling with a 315 cubic-foot-per-minute air compressor having a maximum working pressure of 120 psi. These specifications are much lower than for normal field usage but they proved to be adequate for the relatively shallow wells that were and are being drilled for this purpose. In each well, the shallower water zones were cased off with 5½ inch 14-pound casing and, after drilling out, the cement job was tested before making additional hole. Several water producing zones were encountered between 300 and 560 feet which were easily detected by the loss of dust returns and subsequent production of water at the surface. Many of the water producing formations were cored using a 4¾ inch by 10-foot core barrel with recovery being about 50 percent. The water producing formations usually were not more than 20 feet in thickness and consisted mainly of soft to fairly well consolidated sand, sometimes interbedded with a red shale. This same shale very often occurred between water producing formations and often caused major difficulties in treating the water zones. Water production varied between 6 to 50 gallons per minute and the permeability of the recovered cores varied between 0.3 millidarcys to 5,400 millidarcys.

Before any formation was treated, the cores were analyzed and frequently treated with the proposed grouting fluid. One particular water producing zone of the weeping type had a permeability range of 0.3 millidarcys to 7.8 millidarcys and an average porosity of 27 percent. Laboratory tests with the formation samples showed that it was impossible to force water through inch-long cores at differential pressures up to 100 psi. This fact was confirmed in the well where it was not possible to pump water into this formation at less than fracturing pressures. Naturally, no grouting treatment could be performed and the water was never shut off. Subsequent laboratory work showed that the relatively soft sand was crushing at the pressure side of the core face. The loose particles, so developed, were then forced into flow channel openings which caused a drastic reduction in the flow capacity of the core. Other factors that could contribute to the very low or zero injection rates are, deformation of the elastic rock to decrease flow channel diameters, clay colloids in the water and the fact that a definite volume of water must be displaced in a fluid saturated reservoir to make room for the plugging solution.

Water flow measuring system. Past information derived from field experience showed that reported water producing rates were often estimates. For the controlled research program, it was deemed necessary to devise an accurate method to measure the flow rate from each water producing zone. Figure 2 is a schematic diagram of a gathering and air-water separating system that was found to be of great value. Produced water is routed to a pump where it flows through a calibrated weir. A continuous record of the flow through the weir can be made which will give an indication as to when the water bearing zone is completely penetrated by watching the slope of the curve on the chart paper. This method of



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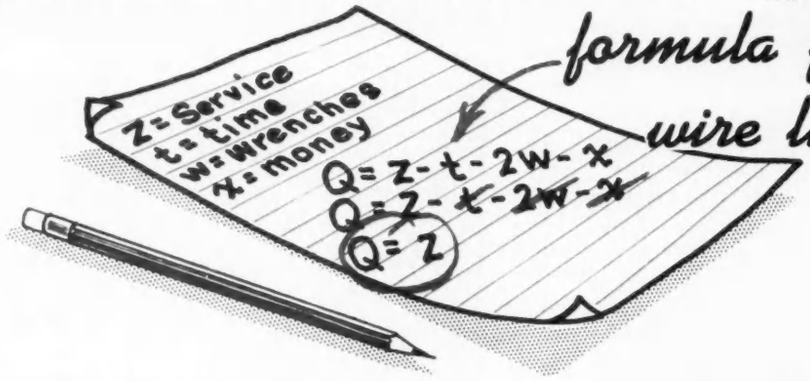
AROUND THE WORLD



formula for improved wire line service!

Pardon us, if you will, for taking a few mathematical liberties, but this seemed an interesting method of pointing out the advantages of adding "Q" to your well service problem equation.

"Q" in our pseudo equation represents ***Quick Lok***. ***Quick Lok*** in your wire line well service setup means the fastest way to change a wire line tool at the wellhead with no sacrifice in strength, safety or compromise in the operation of any wire line tool.

"Making up" a ***Quick Lok*** involves pushing the two segments, Body Assembly and Pin Section, together and rotating the Pin Section 90° either way, until the spring loaded slide (in blue) snaps into place. When it comes time to "Break out," the Slide is lifted and the Pin Section is again rotated 90° and withdrawn. That's all there is to it.

While the time savings realized by not having to completely remove the tools from the lubricator are obvious, another advantage, perhaps of almost equal importance, is that of decreased wear and tear on the costly tools themselves through the elimination of repeated making and breaking of threaded connections every time a tool is to be changed. Also, once ***Quick Lok*** connections are installed in your well service program, the usual pipe wrenches are no longer needed.

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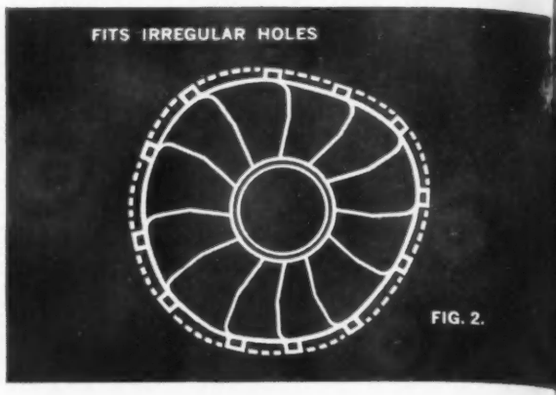


FIG. 2.

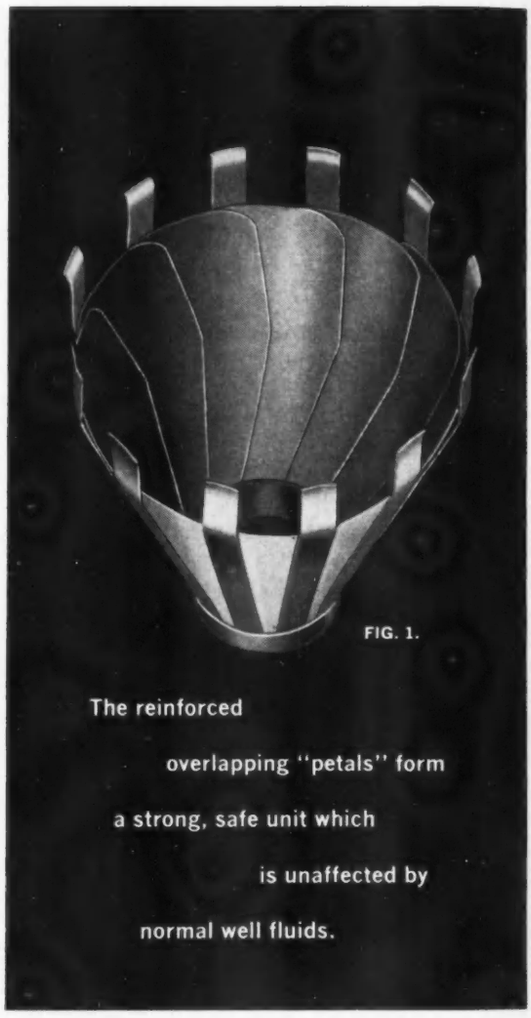


FIG. 1.

The reinforced overlapping "petals" form a strong, safe unit which is unaffected by normal well fluids.

For Problem Cementing, where a lower permeable (or weak) zone must be protected from the cement slurry, or from sloughings and cavings, the Baker METAL PETAL Basket is safe and successful.

A number of "petals" made of flexible sheet steel are mounted on reinforcing spring-steel ribs which in turn are mounted on a ring to form the Basket. This all-metal construction provides unusual strength; there is little likelihood of damage to the unit while running in the well.

Safe, Automatic Operation—While running in the well, upward pressure of the fluid (see Fig. 5) tends to close the petals, thus providing fluid passageway between the Basket and the wall of the hole, without distortion or damage to the Basket. As soon as the casing comes to rest, upward pressure by the fluid is relieved and the petals expand to contact the wall of the hole (see Fig. 6). Any tendency of fluid to move downward then presses the flexible petals more firmly against the entire circumference of the hole. Solids which are strained from the fluid serve to build a bridge inside the Basket, which is thus converted into a one-way annular packer of great strength and effectiveness (see Fig. 7).

Fits Large or Irregular Holes—The "Metal Petals" not only expand to contact the entire circumference of large-diameter holes (see Fig. 4) but also pack-off in holes of irregular shape as shown in Fig. 2. The independent action of the individually mounted overlapping petals permits successful use of Baker Metal Petal Baskets in casing programs with minimum clearances (see Fig. 3).

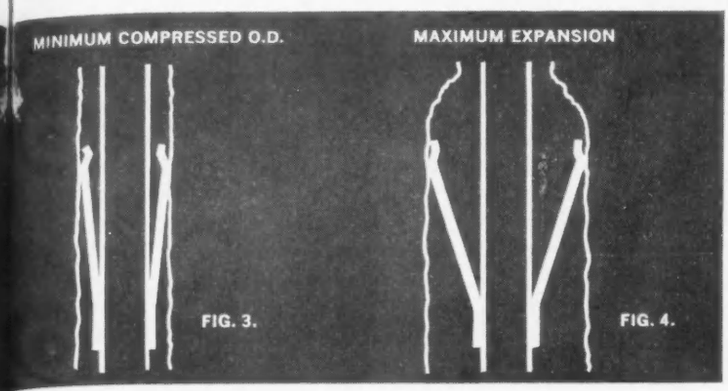
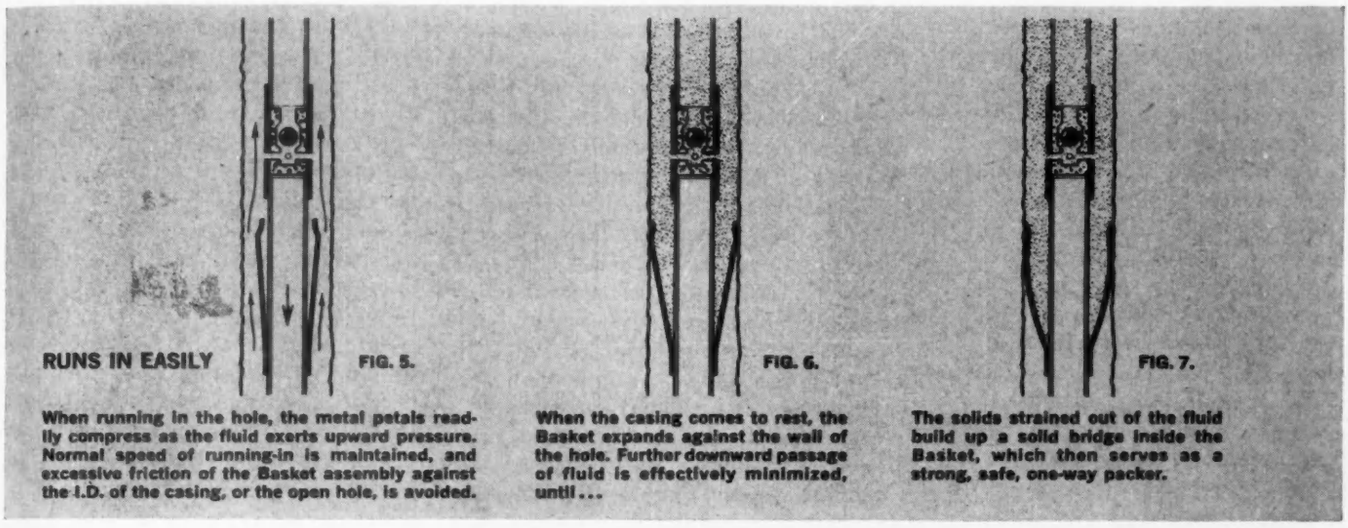


FIG. 2.
FITS IRREGULAR HOLES – The Basket expands to contact the entire circumference of irregularly shaped holes.

FIG. 3.
MINIMUM COMPRESSED O.D. – Less than ½" greater than coupling O.D. – providing ample running-in clearance.

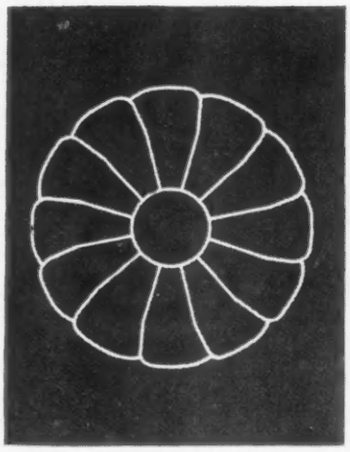
FIG. 4.
MAXIMUM EXPANSION – The Basket expands to more than twice the diameter of the casing on which it is run in sizes 5½" and larger.



When running in the hole, the metal petals readily compress as the fluid exerts upward pressure. Normal speed of running-in is maintained, and excessive friction of the Basket assembly against the I.D. of the casing, or the open hole, is avoided.

When the casing comes to rest, the Basket expands against the wall of the hole. Further downward passage of fluid is effectively minimized, until . . .

The solids strained out of the fluid build up a solid bridge inside the Basket, which then serves as a strong, safe, one-way packer.



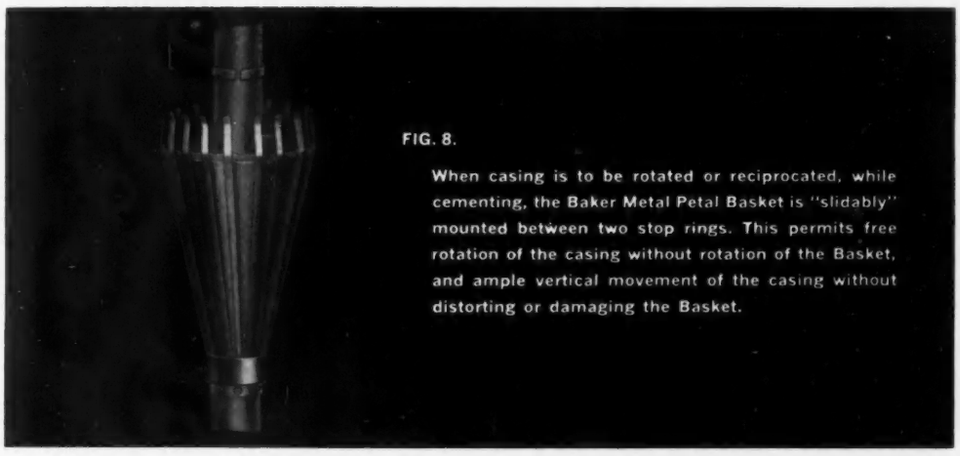


FIG. 8.

When casing is to be rotated or reciprocated, while cementing, the Baker Metal Petal Basket is "slidably" mounted between two stop rings. This permits free rotation of the casing without rotation of the Basket, and ample vertical movement of the casing without distorting or damaging the Basket.

Mountings Meet All Needs—The Baker Metal Petal Basket is furnished as a separate unit for installation to meet any requirement. Generally it is *slidably* mounted by spacing two split stop rings some distance apart to allow free travel of the Basket and free rotation of the casing. Baskets can be furnished affixed to either a *plain* or a *perforated* nipple to meet cementing requirements.

Baker Metal Petal Baskets are used extensively in combination with Baker Stage Collars to retain and support the cement slurry for the second stage. Baker Casing Centralizers are normally used above and below such combinations to provide uniform annular clearance.

Any Baker representative will give specific recommendations for the use of Baker Metal Petal Baskets; or see the BAKER (or Composite) Catalog.

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measuring proved to be very efficient and greatly aided in the evaluation of the many materials that were applied in the seven wells drilled for this research project.

Use of packer is important. Research conducted in these wells confirmed earlier thinking that the technique of placement of the sealing solution is one of the most important phases of the entire program. The results of previous applications had shown that it was possible for the grouting solutions and/or the displacement fluid to enter barren formations or shale bodies in preference to the water bearing zones. This occurrence greatly reduced the efficiency of the treatment and prevented a true evaluation of the sealing material. For this reason, applications in the test wells were performed under a packer so that a more precise placement could be obtained. The presence of sloughing shale just above the horizon being treated greatly complicates finding a packer seat and, sometimes in the removal of the packer from the hole. However, experience has shown that the proper isolation of the formation being treated is greatly desired and should be done whenever possible. One packer used for this type of placement is a modified retrievable tool equipped with mechanical support slips which have enough overtravel to permit engagement in enlarged holes. This system is known as a side wall anchor and has been extensively used for off-bottom drill stem testing. The packing element is a rubber sleeve of the expanding shoe type. A hydraulic hold down device is incorporated in the tool to help prevent unseating of the packer when excessive differential pressures are applied. Research is also being conducted in an effort to develop new tools that will be more efficient for this type of application.

There are other placement phases that must be considered. The problem of treating all of the variable permeability sections of the water producing zone is a major consideration. In addition, it is felt by most people that a fracture must not occur during the placement of a true liquid grouting solution. If one should occur, the solution will probably follow the fracture and not saturate all of the water bearing zone. This fact was fairly well proven in the test wells where fractures were deliberately made in a few formations in an effort to shut off water with negative results. Under most conditions, it is not possible to accurately predict at what pressure a fluid saturated formation will fracture. This fact alone certainly compounds the difficulties of the general placement problem.

Many ideas, as far as materials and techniques are concerned, were developed before and during the test well research program. Most of the ideas were based on sound judgment but, it must be admitted, that some rather fantastic approaches were taken in an effort to not pass up any idea that had a remote possibility of succeeding.

Placement of materials in test wells. When a water zone was encountered in the test wells and an analysis of the cores completed, the treating procedure was planned and the placement made with a particular material. Working under these controlled conditions, it was possible to field evaluate many materials as well as acquire a much better understanding of the problem.

The initial step in the treating procedure was to blow the well with air long enough to clean the hole of cuttings and heaving shales. After a steady water flow rate was recorded, an attempt was made to pump water into the formation to determine if the zone could be treated with a sealing material. The result of many tests of this type developed a rough rule of thumb. This rule is, "water can be pumped into the water bearing formation at an average rate of about ⅓ to ½ the water producing rate." Continued work along this line brought to light some interesting and pertinent information. A test was made to determine the effect of blowing or producing the well on the injection rate into the formation. A water producing formation 13 feet thick was pumped into with water after the fluid in the hole had been allowed to come to a static condition. After blowing the well for four hours, a three centipoise grouting solution was spotted, the packer set, and the solution pumped into the same formation. The comparative pumping rates are shown in Table 1.

TABLE 1

Volume Pumped	PUMPING RATE (BARRELS PER MINUTE)	
	Before Blowing	After Blowing
1 Barrel	0.5	0.5
Next 0.5 Barrel	0.3	0.5
Next 0.5 Barrel	0.16	0.5
Next 0.5 Barrel	Discontinued	0.5
Next 0.5 Barrel	...	0.4
Next 0.5 Barrel	...	0.3

The planned volume of sealing fluid had been displaced after pumping 3.5 barrels which is the main reason pumping was stopped. The water zone was completely sealed. The success of this procedure caused its adoption, whenever possible, in all future treatments.

TO BE CONTINUED

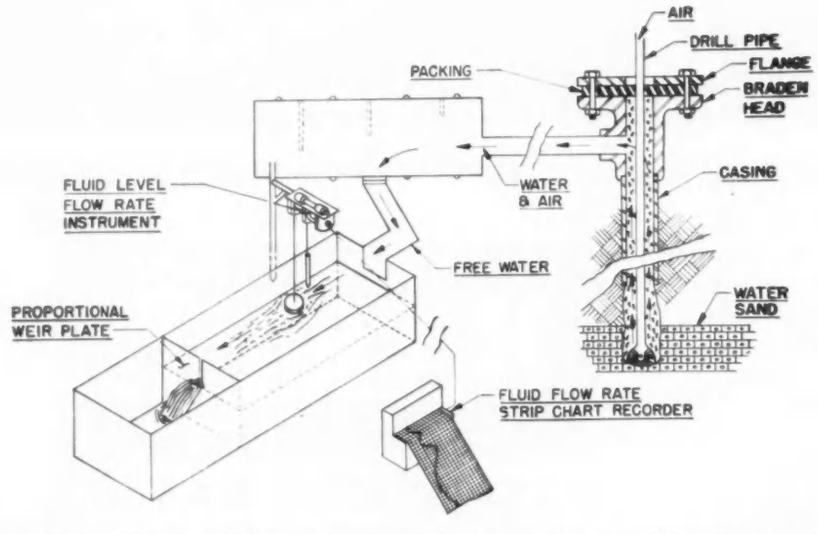

FIGURE 2—Schematic diagram of water gathering system and calibrated weir plate developed to accurately determine water flow rates in gallons per minute from air-drilled test wells.

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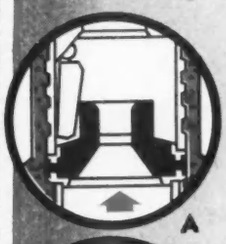
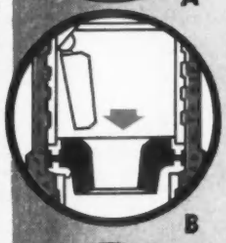


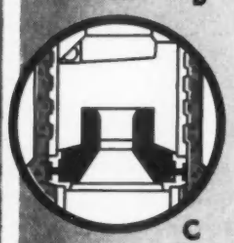
A

Circle A, a view 90° from that of the large illustration, shows the Filrite valve in running-in position. The resilient diaphragm valve remains closed until the differential fluid pressure across it overcomes its inherent resistance to open.



B

Circle B shows the rubber diaphragm inverted by pump pressure as the well is being cemented. Filrite is full opening and will allow passage of a bridging to actuate other equipment which might be installed on the casing beneath a Filrite Collar.

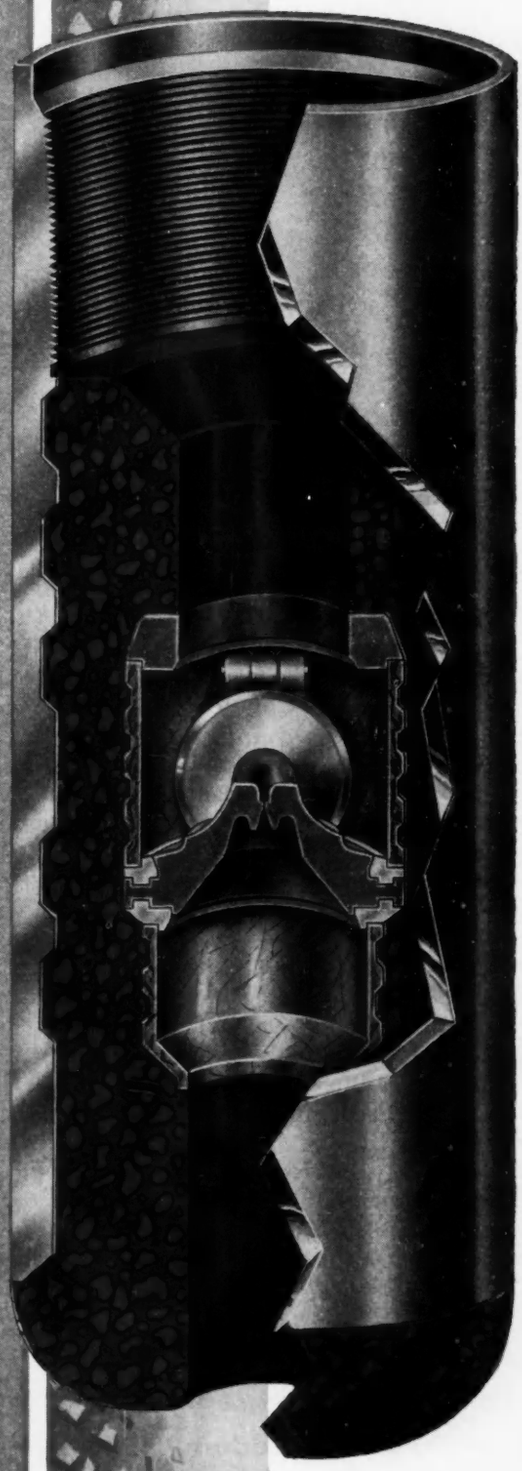


C

Circle C shows the spring-loaded flapper valve in closed position after being released by inversion of the diaphragm. The flapper valve in the Larkin Filrite equipment is very strong and has no depth limitations.

Available but not illustrated:

Filrite Collar, Filrite Geyser Shoe and Filrite Geyser Collar



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Needed: Wider well spacing

Here is a timely, authoritative appraisal of the controversial well spacing problem, including a possible solution

By R. M. Williams, Assistant General Attorney
Phillips Petroleum Company, Bartlesville, Oklahoma

THE GRAVE problem of unnecessary drilling in the United States calls for immediate action. High costs and economic waste are crippling the industry. But, there is no justification whatever for doubling or quadrupling these already excessive costs by the unwarranted drilling of from two to four times as many wells to recover the same amount of oil and gas.

The basic approach is to discard the erroneous test of how many wells can be drilled at a profit and consider the true test of how many wells are needed to efficiently recover the oil and gas. The next logical approach would be a flexible, step-wise program of spacing. By starting with wide spacing, the regulatory agency can make no mistake. It can later adjust the spacing to the facts. It otherwise enters upon the road of no return.

Initial legislative efforts in well spacing were primarily an attempt to eliminate indiscriminate drilling anywhere on any size or shape tract, not to determine the ultimate optimum well spacing for the most efficient recovery of oil and gas from a pool. And even though some of the later statutes restrict drilling to the fewest number of wells required to drain an area efficiently and economically, administrative procedures limit application.

Regulatory agencies feel that the initial spacing order is permanent and that the extent of effective drainage must be determined at the time the order is made. While the language of the statutes lends some support to this view, in practice it is wrong.

Normally, to be effective, a spacing order must be entered very early in the life of a pool, before too many closely spaced or off-pattern wells are drilled. Spacing is often requested at the time of completion of the first well so that those drilling subsequent wells will know where to locate them. But, this is too early to have satisfactory proof of the extent and nature of the reservoir, its performance, production history and other facts needed to determine ultimate optimum spacing.

The result, particularly if there is a contest, is that the regulatory agency will either arrive at a compromise or establish units sufficiently small that it knows will be drained. In either event the spacing units are considerably smaller in size than the optimum for the pool.

At the time our present laws and practices evolved, thinking was geared to the outmoded concept of "more wells, more oil." Today, however, engineers and, other production technologists agree that more wells do not mean more oil, and that ultimate recovery is independent of spacing. For all practical purposes, a pool developed on the basis of wider spacing will efficiently produce as much oil and gas as if it were developed on closer spacing. More wells may make possible a potentially greater current rate of production, but no significant increase in ultimate recovery can be expected.[1]

Instead of "more wells, more oil," the fact is "more wells, more proration." Thus, more wells today do not necessarily mean more oil "in my life-

"In this country we continue for the most part to drill oil wells predominately on the basis of one well to 10, 20 or 40 acres; and our natural average production in 1957 was 12 barrels of oil per well per day.

Producers in the United States cannot hope to compete with such a standard."

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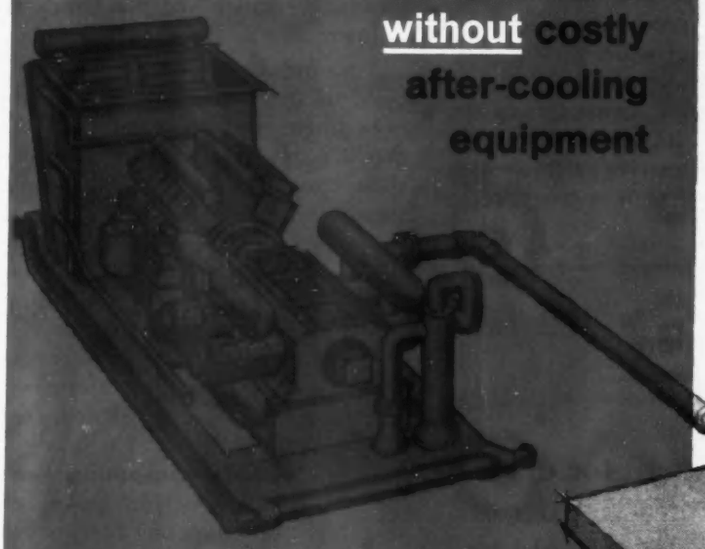

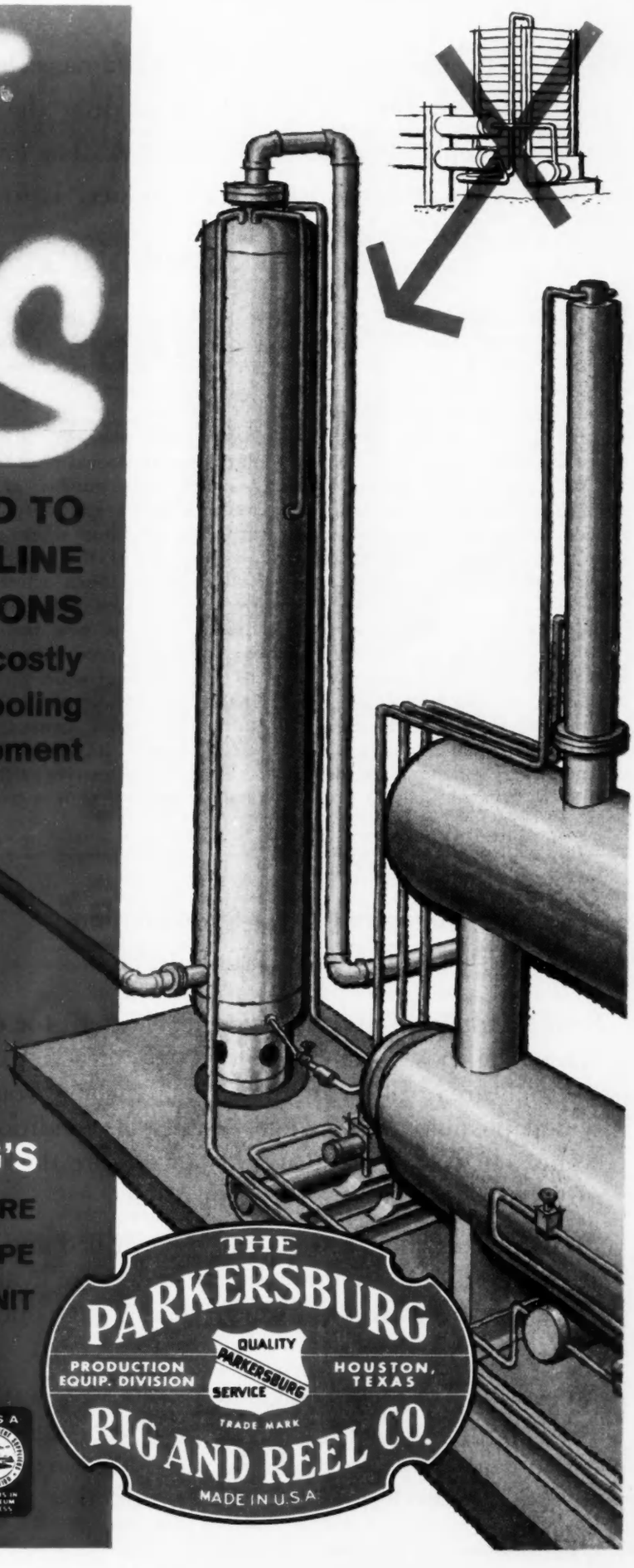

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"Excess wells unnecessarily occupy and damage the landowner's surface. The more wells, the greater the risk of improper completions and inefficient wells. The lower the per wells allowable, the less apt a producer is to do the proper remedial work."

time," a phrase sometimes used by royalty owners advocating close spacing. The better concept would be to prorate wells rather than production. An editorial in WORLD OIL spoke wisely when it said:

"Other industries do not build plant capacities far greater than will provide sufficient products to satisfy demand, then operate the plant far below capacity and for only part of the time."[2]

This, however, is exactly what the petroleum industry is now and has been doing over the years by our present practice of well spacing and resulting oversupply and proration. Against a fixed market outlet, a reservior needs only the minimum number of properly located wells to produce the required volume at individual well rates which will not result in reservoir damage.

Additional reserves. The need today is for additional reserves and not a mere excess number of prorated wells. A wider spacing pattern will expedite the time when the limits and reserves of the particular pool will be known. Such action also will free capital, men and equipment for the discovery of new reserves, since the increased producing rates of a fewer number of wider spaced wells makes the drilling of more exploratory wells and the search for new reserves far more attractive.

If, once the reserves are discovered and defined, there is a need for an increased rate of production, additional infill wells can be drilled in known pools under known conditions.

Economics. Many people, and particularly regulatory agencies, have tried to close their ears to the high costs and economic waste crippling the industry today. The approximately 7 million barrels of domestic oil and 32 billion cubic feet of gas per day required to meet the present demand cannot be found and supplied by an economically sick industry whose costs exceed what the public will pay for its products.

Inflation, increased costs of steel, higher wages, deeper and more inaccessible drilling, and the many more costly scientific methods and devices used in finding, drilling for, and producing oil today have resulted in a tremendous increase in cost.

Oil found per foot drilled declined from 25 barrels in 1951 to 11 barrels in 1957. Newly discovered fields are generally smaller and the sands are thinner.

The industry cannot control the price of steel, wages and other costs of a single well. To the extent that product prices could be increased, these costs are passed on to the consumer; but there is a limit to what he will pay, and the industry must stand all over and above that amount. This absorbs capital that would otherwise be used in finding and developing new reserves. At the present time, the industry suffers more from overinvestment than from overproduction.

Foreign oil and competing fuels. The importation of foreign oil and the threat of competing fuels is basically a problem of economics; for so long as they can be produced and supplied at a cost substantially less than that of domestic oil, they will continue as a threat. Under such circumstances, more and more producers will go to foreign fields where they can operate more cheaply. Tariffs, quotas—whether voluntary or compulsory—or other legal restrictions may temporarily serve to hold a finger in the dike; but economic laws still prevail in any long term analysis.

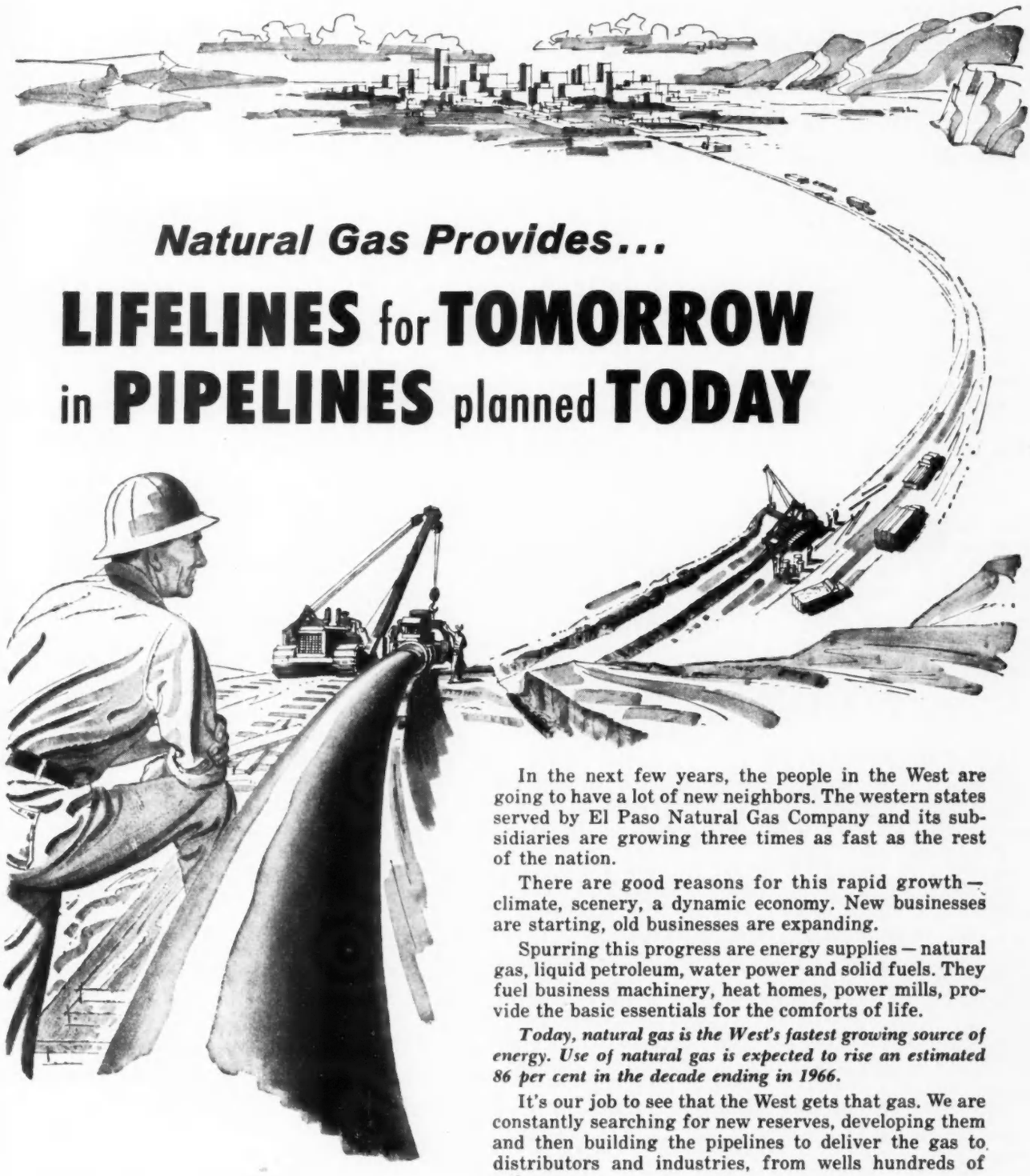
In foreign fields, many wells are drilled on the basis of one well to 640 or more acres, and production rates of 1,000 to 5,000 barrels per well per day are not uncommon. In

Suggested Three-Step Solution To the Well Spacing Problem

Step 1: Establish an initial spacing pattern for development purposes, whether it be by statewide order or for each area of development. Such spacing would be widest possible thought likely under all conditions. It would not be final, and would not require the degree of proof as would a permanent order.

Step 2: After enough wells had been drilled and when the required information and evidence were available, further hearings would be held to determine optimum spacing.

Step 3: The regulatory agency would have authority to permit infill drilling and closer spacing if more wells are indicated by either spacing re-evaluation or a need for an increased current rate of production.



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"... Producers drilling on small tracts in Texas are allowed many times more oil per acre than producers drilling on standard spacing. This is ... merely a grossly inequitable distribution of allowable production."

this country we continue for the most part to drill oil wells predominantly on the basis of one well to 10, 20 or 40 acres; and our national average production in 1957 was 12 barrels of oil per well per day. Producers in the United States cannot hope to compete with such a standard.

Other considerations. It is claimed that each well drilled is entitled to a minimum allowable to repay well costs and operating expenses, but the accumulation of such allowables and the urge of each producer to get his allowable can cause pools as a whole to produce in excess of their maximum efficient rates, resulting in actual physical waste of oil and gas.

Excess wells unnecesarily occupy and damage an excess of the landowner's surface. The more wells, the greater the risk of more improper completions and inefficient wells. The lower the per well allowable, the less apt a producer is to do the proper remedial work. Many other such conditions could be named.

Possible solution: step-wise spacing. The most logical solution although subject to many problems, would be a flexible, step-wise program of spacing. (See box).

The step-wise approach has been adopted in some states, for example, New Mexico and North Dakota. There, the regulatory agencies have entered temporary wide spacing orders pending further information from additional development. The new and progressive commission of Utah, following the lead of New Mexico, has adopted such an order in the Aneth area. In some instances, however, it has been with some question in the mind of the regulatory agency as to its authority under the statute.

By starting with the widest likely spacing at the outset, wide optimum spacing is assured since additional wells can always be drilled if the evidence or circumstances so dictate; but with initial dense spacing, it is virtually impossible and grossly inequitable to go to wider spacing. By starting with wide spacing, the regulatory agency can make no mistake, for it can later adjust the spacing to the facts.

Particularly with respect to the new miscible phase recovery, wider well spacing is highly desirable, and may prove necessary from the standpoint of economics and the available supply of LPG, to begin such operations before the pressure is too far depleted. If this is to be accomplished, it is essential that wider initial spacing be adopted to supply the necessary information before it is too late.

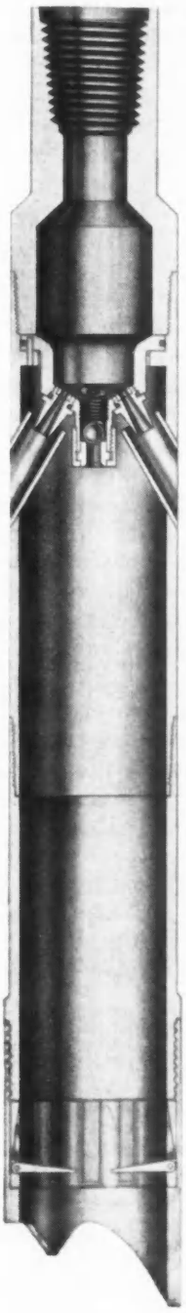
Why unitization is needed. Early unitization would further reduce costs by necessitating fewer wells. A number of big units have been created in the past few years in connection with which more than half of the wells previously drilled were shut in immediately as being unnecessary. Far better that these hundreds of costly wells had not been drilled and their cost applied to some more scientific and better method of recovery.

The early widespread development of an entire pool by wider spacing allows all to share in the production from the pool at an earlier date and affords a more equitable distribution of the oil and gas. Under dense spacing it is oftentimes three to five years or longer before development reaches many parts of the pool, giving to those in the portion developed

Six Advantages of Wider Spacing

1. Eliminates the high cost and resulting economic waste of drilling unnecessary wells.
2. Tells more quickly the extent, nature and producing characteristics of the entire reservoir.
3. Makes possible earlier evaluations as to whether there is a large, small or no gas cap; where the gas-oil and water-oil contacts are located; and if there is an effective water drive.
4. Permits an early appraisal of the volume, nature and availability of gas so that the size, location and type of gas gathering lines, and the needed processing, compression and marketing facilities can be determined and made available.
5. Early knowledge of the extent and reserves of a pool can aid materially in obtaining an early and adequate market for the oil or gas.
6. Of extreme importance is the possibility of fluid injection or other cooperative method of operations, which could, by early action, result in the recovery of substantially more oil than could otherwise be obtained.

A Good Name* to remember



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early an undue advantage and a disporportionate share of the oil and gas from the pool.

Where a pool of any size is developed on the basis of one well to 10, 20 or 40 acres, it is physically impossible to amass enough drilling equipment, men and materials to develop the pool quickly enough for all to share equally. The answer to the royalty owner who wants more wells to get all the oil and gas he can "in his lifetime," is that with limited market demand, more closely spaced wells on his land delays the drilling of wells on another landowner's property, thus giving him an unfair advantage of the market. All landowners should have the right to their fair share of the oil "in their lifetime."

Pooling within units. Any effective and realistic spacing law or regulation must of necessity provide for pooling of interests within the prescribed spacing units. Unless the interests are pooled, there is no way to limit drilling to a size unit larger than the smallest tract without discriminating against or confiscating the property of the owners of such land. Texas attempts to avoid this by the so-called granting of exceptions, but such exception not only destroy the rule but award those getting exceptions an undue advantage and disproportionate share of the production from the reserves.

Perhaps the most outstanding example of the ineffectiveness of the Texas Spacing Rule 37 is the East Texas Field, the largest in Texas. Although the rule was designed to effect 10-acre spacing, two-thirds of the wells drilled were drilled as exceptions and the average well density for the field is less than five acres.

Common examples have been cited were producers drilling on small tracts in Texas are allowed many times more oil per acre than producers drilling on standard spacing.[3] This is not additional recovery from the pool, but merely a grossly inequitable distribution of the allowable production. Where there is pooling of interests within spacing units, then so long as the spacing pattern is uniform, everyone will receive his fair share of the production no matter how large the spacing units are.

The object should be to recover the most oil and gas as economically and efficiently as reasonably possible, and fairly distribute the production so obtained. There is no justification whatever for the drilling of unnecessary wells. Gone is the day, and rightly so, when operators are permitted to obtain an undue advantage by applying the law of the jungle to the exploitation of a common supply of oil and gas.

The solution here proposed is possible within the framework of the present statutes in a number of states. It is for all who are interested in the proper administration of the conservation laws to aid the regulatory agencies in such application of their laws.

In other states it will be necessary to modernize and amend laws and regulations, to provide for a flexible well spacing program. This very definitely requires provisions for the establishment of spacing units and the polling of interests within spacing units. It requires that arbitrary top statutory limits be removed from law and left to the judgment of the regulatory agency.

The grave problem of unnecessary drilling in this country calls for immediate action; but as in the case of other reforms, particularly in the field of conservation of oil and gas, the task will not be easy. There will be immediate objections, most for selfish or ill-advised reasons; and difficulties will be offered as to the particular mechanics to be employed in a given case.

Objections can be overcome and difficulties in individual instances resolved, but only if those who care do something about it. Everyone interested in the welfare of the oil and gas industry, whether he be lawyer, engineer, production man, landowner, consumer or regulatory official, should do his part. He should take every opportunity to solicit the aid of professional and trade associations, royalty owner groups, state regulatory groups, state legislators, and all others who may be able to help resolve this problem.

This article is a revised and condensed version of a paper presented before the Section of Mineral and Natural Resources Law of the American Bar Association, August 26, 1958.

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About the Author

R. M. Williams, assistant general attorney, Phillips Petroleum Company, Bartlesville, has served in the company's legal department since 1944. Born in Omaha, Williams attended high schools in Nebraska and Missouri and the University of Oklahoma where he received his LL.B. degree in 1922. He was in private practice of law at Oklahoma City before joining Phillips. Williams, who has dealt largely with oil and gas law during his entire professional career, helped draft the Oklahoma conservation laws, as well as those of other states, and has participated in many of the cases involving their validity and application. He was the principal author of the Oklahoma unitization law, and for a number of years has been representative of the state of Oklahoma on the legal committee of the Interstate Oil Compact Commission. He is presently chairman of a subcommittee appointed to revise the Compact's suggested form for an oil and gas conservation statute.

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[1] "Conservation in the Production of Petroleum" 1957, (p. 337) by Erich W. Zimmerman.
[2] "Costs—Biggest Problem of All" WORLD OIL, May 1958 by Warren L. Baker.
[3] Erich W. Zimmerman and Robert E. Hardwicke.

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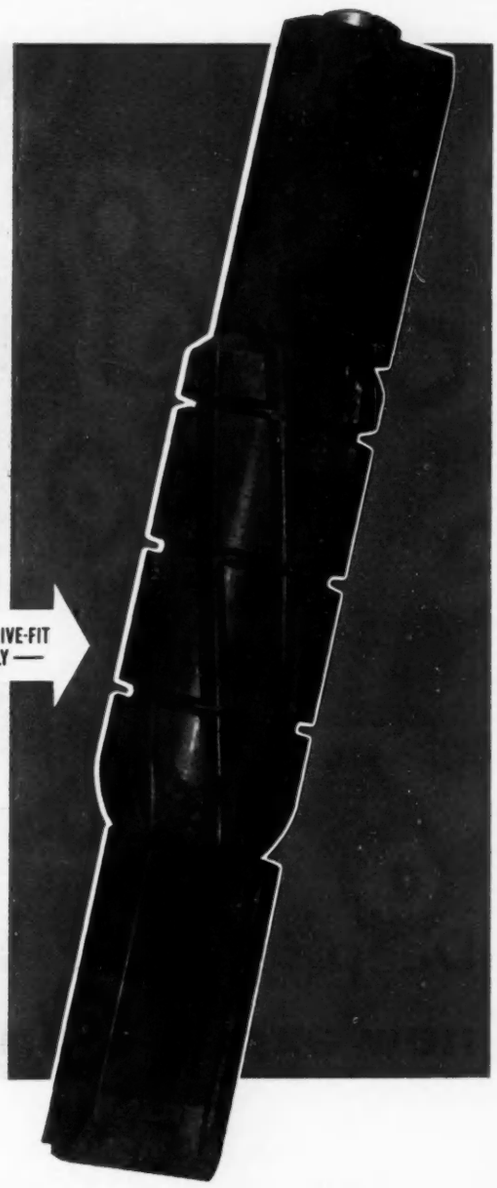

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FIGURE 1—Surveyor working with alidade, in seismic exploration in Israel's arid hills.

Deep seismic results mean new exploration in Israel

Pattern shooting yields good records in areas where single shot techniques gave poor results

By Herbert I. Harris, Chief Exploration Geologist
Israel-Mediterranean Petroleum, Inc.
New York City

IN SPITE of nearly five years of intensive exploration and the drilling of more than 30 dry holes that netted only one small oil field, there is evident in Israel today a new feeling of optimism for the country's petroleum future. This is not the result of an imminent discovery, but is due to the success of the persistent efforts of two American-backed independents, Pan-Israel Oil Company, Inc. and Israel-Mediterranean Petroleum, Inc., to solve geophysical problems that have plagued Israel's oil search efforts from the very beginning.

The first test well in Israel to be located on the results of deep seismograph mapping, Hulda 1, was being drilled in the fall of 1958, by these two companies about 16 miles northeast of the Heletz oil field in the southern coastal plain area. It was to test a fault trap uncovered by refraction and reflection seismograph on a gravity lead. A second structure in the southwest Negev, mapped by the seismic crews of these two companies, has proved to be an outstanding closed anticline extending to great depth. Naphtha Petroleum Corporation, an Israeli firm, has begun making preparations for the early drilling of this prospect.

The new feeling of confidence so evident within Israel's petroleum industry stems from the realization that the unconformities in the near surface rocks are masking the deep structures, and that ignorance of this fact was the cause of much effort being expended on prospects which were washing out at depth. Previous to the seismic work being carried out under the direction of Pan-Israel and Israel-Mediterranean, exploration had been limited to structure drilling to average depths of 1,000 feet and to the uncertain, irregular results of locally available seismograph crews and equipment. Some 14 wildcats were drilled in Israel's coastal plain based only on the scanty information provided by these means. The complete lack of even minor indications of oil or gas convinced many geologists that most, if not all, of these wildcats were far off structure.

In an attempt to explore more thoroughly the subsurface of Israel's coastal plain, where oil had been discovered at Heletz in September, 1955, Pan-Israel and Israel-Mediterranean, upon the advice of geophysical consultants in Tulsa, contracted to bring into the country modern seismic equipment to be staffed by American-trained crews. In October, 1956, the shipment was being readied when the Israeli Sinai campaign started. This was followed by the temporary ban on travel by Americans to the area. However, in 1957, initial operations got under way with a refraction line in the Lachish area, which is east of Heletz.

This initial refraction work proved that a limestone bed about 800 feet higher than the sands producing a few miles to the west, and a second limestone horizon about 700 feet below the producing sands, both could be mapped. These beds were followed at depths ranging from 5,000 to 8,000 feet, marking the first time in Israel's short exploration history that deep, continuous seismic mapping had been accomplished. Seismic charges up to 500 pounds were used in the refraction survey, with charges detonated at distances ranging from 21,650 to 32,480 feet from the recording line. Single shot holes were drilled, rang-

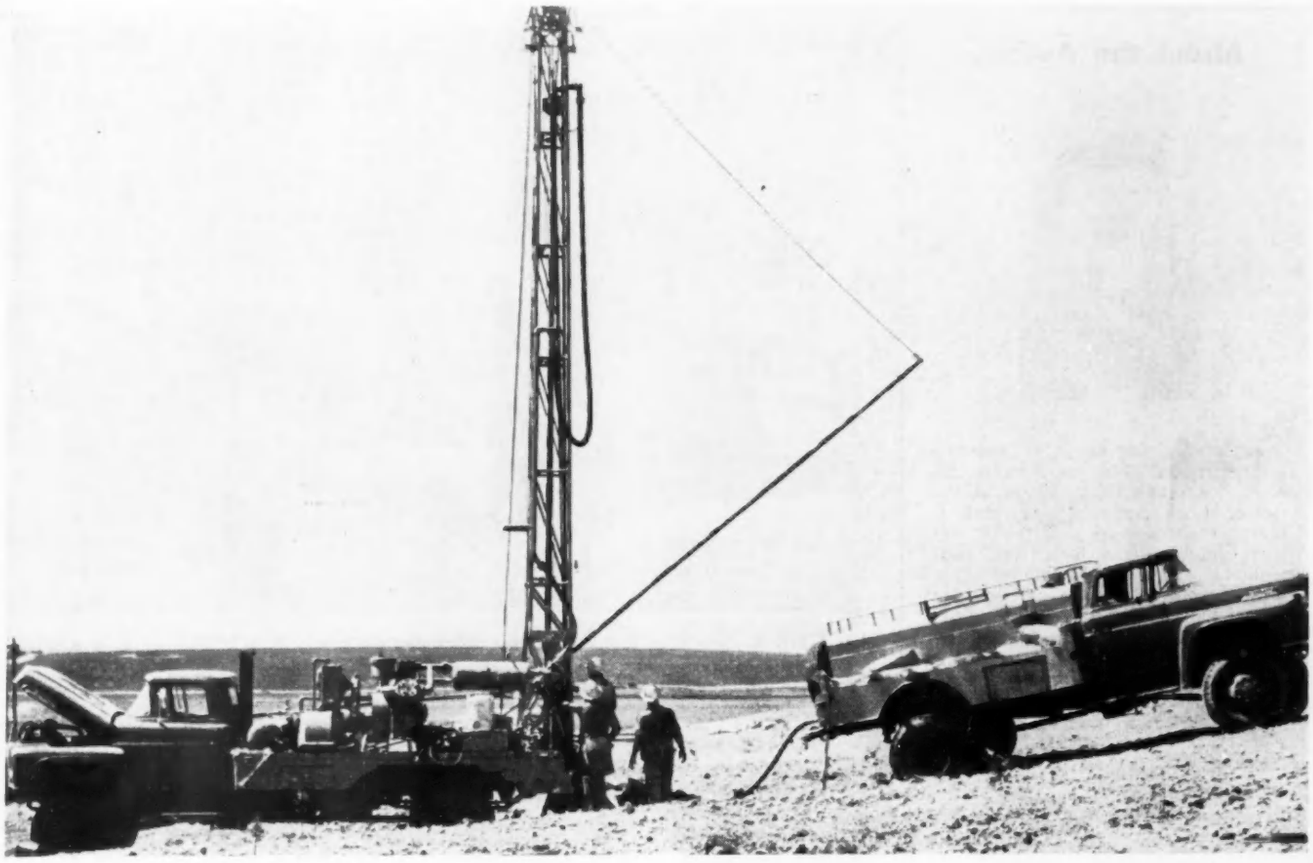

FIGURE 2—Shot holes, varying in depth from 100 to 600 feet, were drilled in Israel seismic surveying. Here is a side view of the drilling unit employed. Drill stem is suspended by cat line from mast in operation of drilling truck at left. Compressor was available for air drilling—used except in areas where damp chalk caked on drill pipe, causing loss of volume. In such cases, it was necessary to revert to conventional mud drilling. Water truck at right provided water when needed.

ing in depth from about 100 feet (in areas where bedrock was near the surface) to a record 600 feet (where old dune sands stood up as a range of hills). Locally-made explosives were used in conjunction with electric detonators imported from England.

One of the results of the refraction work was the proof of deep-seated faulting. Although suspected, it had never been established by structure hole drilling. In the Hulda area, the fault pattern became so complex that it was decided to check the refraction map with reflection shooting. Cables, jumpers, and some 600 geophones were air-freighted to Israel for this purpose. In addition, 8-inch paper was substituted for the 6-inch paper previously used, so that 24 traces could be easily recorded, 12 straight and 12 semi-mixed.

Reflection experimentation was started in an area which had yielded no reflections in previous attempts by the local crews. However, electric logs of deep dry holes in the area indicated several good lithologic breaks in the Upper and Lower Cretaceous and Upper Jurassic to depths of about 8,000 feet. Deeper data were unknown since none of the wells had been drilled below this depth. Based on the electric logs, it appeared that there must be several reflecting horizons.

Surface conditions consisted of from five to 60 feet of soil and unconsolidated to semi-consolidated sand lying unconformably on chalk and chalky limestone with flint nodules. Single holes with single geophones produced records completely masked by noise with perhaps a faint trace of deep energy returns. Experimentation continued using single shot holes but with 18, 36, and 72 geophones per trace. Distance between geophones was tried with 16 feet and 33 feet spacing and with layouts of 785, 1,180 and 1,575 feet. The records were improved in quality with the addition of geophones, although 72 geophones per trace were not necessary. A spread length of 1,575 feet using parallel jumpers with 33 feet between phones proved to be optimum, although in difficult areas 1,180 foot spreads proved more precise. However, the high frequencies natural to chalk-limestones were so completely masking the deep energy returns that pattern shooting had to be resorted to in order to cancel the surface noise. Record quality became usable only when random noise was cancelled out by drilling multiple holes in conjunction with multiple geophones.

Since only one shot hole rig was available for the work, it was necessary to drill a minimum amount of footage while still getting usable results. Experience showed that if the unconsolidated cover was thin, nine holes drilled to 40 feet and loaded with from 35-50 pounds per hole would produce a good record. One of these holes would be taken deeper to provide weathering data. In areas of thicker, unconsolidated cover, patterns of seven 60-foot holes, five 80-foot holes or three 120-foot holes were used. In all cases the total charge ranged from 150-500 pounds. The patterns were usually rectangles or squares, although holes in line were also effective.

Drilling was carried out by air ex-

About the Author

After receiving his B.A. from the University of Minnesota and his M.A. from the University of California (Los Angeles), **Herbert I. Harris** spent several years as an exploration geologist for The Texas Company, working principally in Utah and western Colorado. He joined Pan-Israel Oil Company, Inc. in 1953 and was named as chief exploration geologist for that company and Israel-Mediterranean Petroleum, Inc., in 1957.

FIGURE 3—Shooting truck used in seismograph work in Israel. The truck is equipped with radio antenna. At rear is reel for the shooting cable. At opposite sides of truck are dynamite and cap compartments.

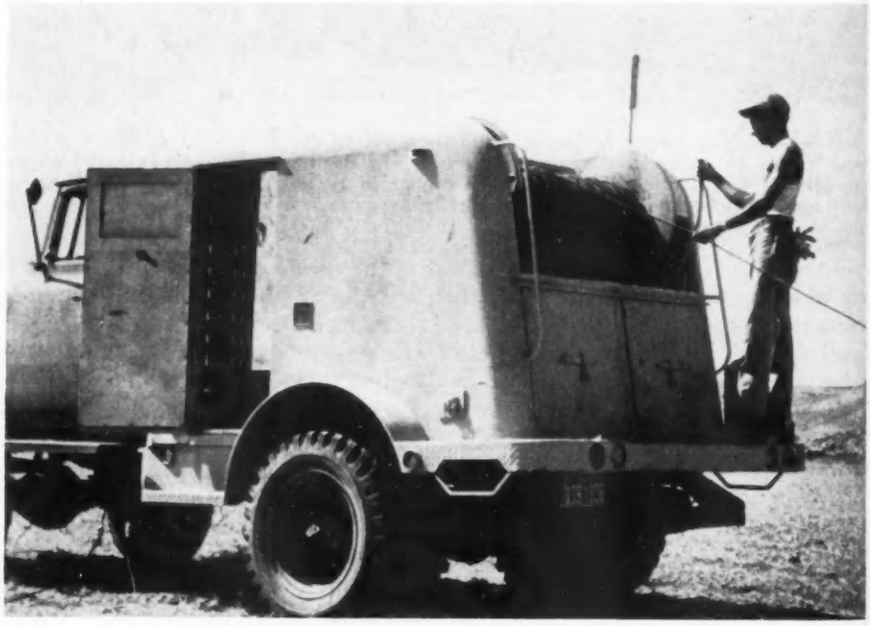

FIGURE 4—Recording truck used in seismograph surveying in Israel. Equipment includes antenna for radio. At rear is the geophone cable. The cable was spread out for distances of 800 to 1600 feet, and geophones were connected at intervals that were varied from 16 feet in some cases to as much as 33 feet in other instances.

cept in some areas where damp chalk caked on the drill pipes, causing loss of volume. In such cases, it was necessary to revert to conventional mud drilling.

Continuous events were mapped at about 700, 950, 1,350, 1,750, and 2,100 milliseconds. Average velocity in the area is around 12,800 feet per second. Thus, maps were produced at depths down to 13,125 feet, the limit for the largest rigs now in Israel.

Perhaps the most important contribution of these deep seismic results was the proof that the structural patterns of folds and faults in the Cenomanian and older rocks are masked by the veneer of post-Cenomanian sediments in Israel's coastal plain. That such a situation existed was long suspected, but no tool had been available to prove the thesis. Thus the deep seismic work has already turned up two closed structures, one of which was previously unsuspected. The second had already had a dry hole drilled on it due to its unfortunate location far down the plunge of the anticlinal axis.

The door has now been opened for a complete revaluation of coastal plain acreage previously condemned by dry holes. Israel's only oil field is producing from a trap caused by loss of permeability across an anticline. This zone of permeability pinchout extends in a long, broad arc, semi-parallel to the Mediterranean shore, and efforts are now being directed toward finding any suitable anomaly within this projected pinchout zone. Although oil has not been found in rocks older than Lower Cretaceous, suitable source rocks and reservoirs in the Jurassic are present. It is now felt that deep tests drilled on good reflection data will also have good chances of encountering production in these formations.

The Pan-Israel, Israel-Mediteranean seismograph crew has moved to the eastern Negev, in an area differing greatly in geology from the coastal plain. The eyes of oil men in Israel are now turned to the Negev to see if deep structural complexities may be uncovered. The numerous structures of this desert area may yet provide Israel with the oil reserves her expanding economy so desperately needs.

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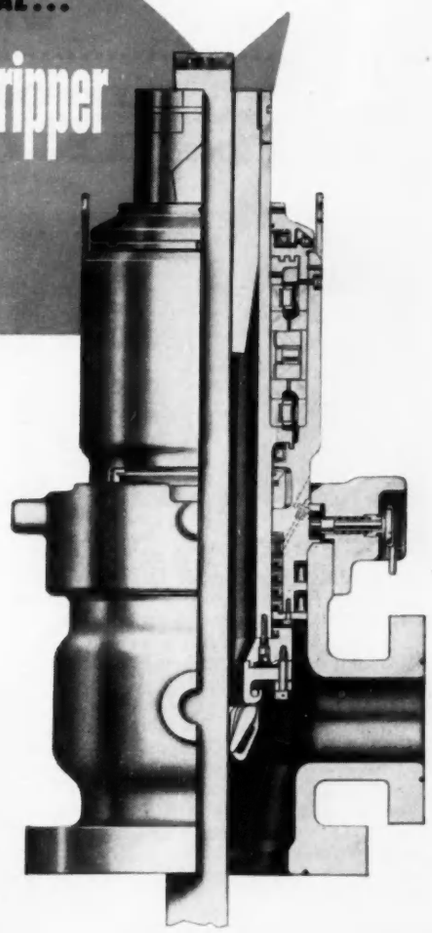

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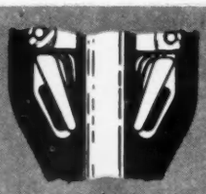

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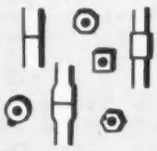

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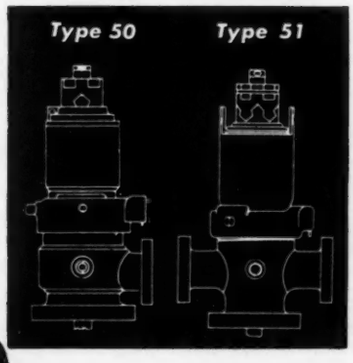

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What's Happening

among MEN in the INDUSTRY

B. D. McCampbell

Marshall Joy

Marshall R. Joy and **B. D. McCampbell** have been elected vice presidents of **AnSon Drilling Company.** Joy is now vice president in charge of operations and McCampbell is vice president in charge of contracts.

George H. Fentress has joined the firm of **Exeter Drilling Company** of Denver, in the newly created position of manager of exploration operations over the Denver Basin and the general Rocky Mountain area. He was formerly associated with Baumgartner Oil Company as manager of exploration and production covering the same areas.

Howard M. Gullickson has become legal manager and general attorney of **Shell Oil Company's** Pacific Coast area exploration and production office in Los Angeles. The appointment became effective on January 1, it was announced. Gullickson replaces the retiring Robert T. Patton.

H. M. Gullickson

Robert L. Parker, president and owner of the **Parker Drilling Company,** Tulsa, has been elected a director to the **National Bank of Tulsa,** it has been announced.

H. W. Brown has been appointed general manager of **Esso Standard (Libya) Inc.** Esso Standard (Libya) Inc., is a wholly owned affiliate of **Standard Oil Company (New Jersey),** with headquarters in Tripoli and was formed in 1955 to carry out oil exploration activities in Libya. Brown began his career with the Jersey organization in 1928 when he joined Humble Oil & Refining Company as a seismograph operator. In 1935, he was employed as a seismograph party chief for The Carter Oil Company and became successively their supervisor of foreign geophysical operations, assistant chief geophysicist, chief geophysicist and exploration manager. He was elected to Carter's board of directors in 1954, continuing in that capacity until joining the parent company in New York in 1956.

H. W. Brown

N. Patrick Hudson has been promoted to the post of assistant sales manager of protective coatings for the **Lion Oil Co., Division of Monsanto Chemical Co.**

John N. Gray

W. H. Cochrane

John N. Gray and **Wallace H. Cochrane** have formed the **Gray-Cochrane Corporation, Petroleum Consultants,** with offices in the C. A. Johnson Building, Denver. Gray resigned as district superintendent for Eastern Venezuela after 21 years with Sinclair Venezuelan Oil Co. Cochrane has been an independent geological consultant for several years in Denver. **Edward R. Haymaker,** recently a consulting engineer with Ball Associates, has joined the Gray-Cochrane Corp. as reservoir-evaluation manager.

E. R. Haymaker

A. L. Hair

J. J. Browne

Changes in executive positions in **General Petroleum Corporation's** Production department were announced recently. **Aldon L. Hair,** Rocky Mountain division superintendent with headquarters at Salt Lake City, has retired. He will be succeeded as superintendent by **J. J. Browne,** special assistant in the company's Los Angeles home office. **P. M. Barry,** assistant to the superintendent of the southern division at Santa Fe Springs, has been appointed special assistant in the Los Angeles office. **W. G. Christensen,** petroleum engineer at Bakersfield, will become assistant to the manager of joint venture operations in Los Angeles.

Bill A. Shelton

Gordon McMeen

A new slate of officers and directors for the **Shelton-Warren Oil Company** has resulted from the recent purchase of the **Lutah Uranium and Oil, Inc. Bill A. Shelton,** who has been president of Shelton-Warren since its inception, was reelected president. **Gordon E. McMeen,** former Lutah president, became executive vice president. **Mansfield Tweedy** of Roswell, N. M., was named treasurer and **Jess L. Warren** was re-elected as secretary. Members of the newly-elected board of directors are **Homer F. Glover** of Roswell, president of Glover Packing Company; **E. S. (Johnny) Walker** of Santa Fe, N. M.; **Guy L. Rogers** of Hobbs, N. M., chairman of the Lea County State Bank; **C. L. Yeatman, Jr.,** of Coleman, Texas, owner of the Yeatman Drilling Company and Shelton, McMeen and Tweedy.

Jess L. Warren

Dr. Phillip W. Choquette, a research geologist, recently joined **The Ohio Oil Co.'s** research center near Denver. A native of New York, he graduated from Allegheny College with a B.S. degree in geology, and from Johns Hopkins University with M.A. and Ph.D. degrees in geology. Previous experience includes a field assistantship and a geologist position with the U. S. Geological Survey in Washington, D. C. He is a member of the Geological Society of America and the American Association for the Advancement of Science.

Dr. Choquette

Tennessee Gas Transmission Company has announced a number of personnel transfers and promotions in the exploration department. **A. C. Baker,** formerly district geologist at Wichita Falls, Texas, has been transferred to Denver as district geologist, replacing **Ray Marvin.** Marvin

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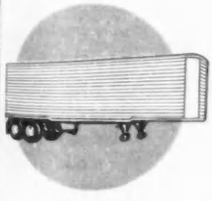
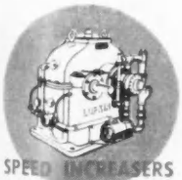


TRAILERS



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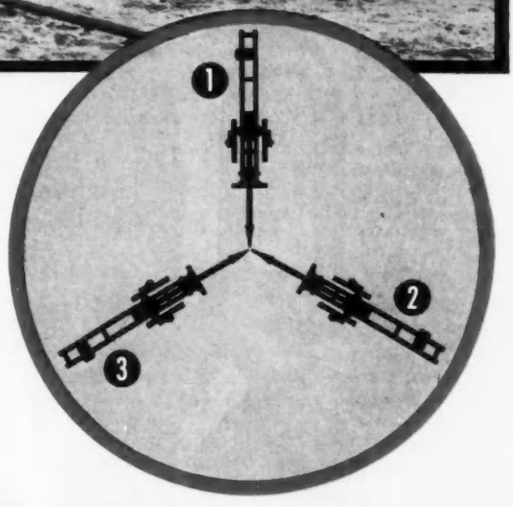

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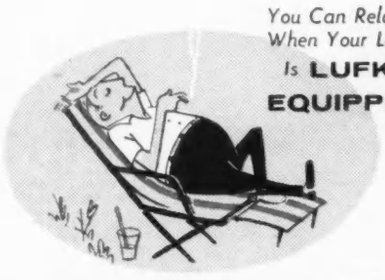

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has been named geologist senior and assigned to special geologic evaluation duties in the Denver exploration district. **Robert G. Welch,** formerly geologist at Wichita Falls, is the new district geologist in that office, replacing Baker. **Don Griffith,** district landman at Wichita, Kansas, has been transferred to Shreveport to serve in the same capacity in that exploration district. **A. E. Feist** has been employed as district landman at Casper, Wyo. He replaces **E. T. Creegan,** recently promoted to district exploration manager at Wichita Falls. **Gordon Asbury, Jr.**, formerly landman junior at Durango, Colo., has been promoted to landman and transferred to the Wichita, Kansas, district.

P. A. Taylor has been named manager of production for the newly acquired Mobil interests in Gabon and the Middle Congo in West Africa. He will take up his new post, headquartered in Paris, France, late in November. Taylor has been chief pertoleum engineer for **Mobil Oil of Canada,** headquartered in Calgary, since 1953. He joined Mobil Oil in 1952. He had previously worked with Royal Dutch Shell in many parts of the world, including Rumania, Holland, Venezuela, Colombia, Trinidad and Egypt.

P. A. Taylor

General James H. Doolittle has retired as vice president of **Shell Oil Company,** effective December 31, to become board chairman of **Space Technology Laboratories,** Inglewood, Calif. Doolittle had been with Shell since 1930, when he left active duty with the U. S. Army Air Force to become manager of the company's aviation department. He had been a vice president and director since 1946. He will continue to serve as a director of the company. General Doolittle began his aviation career when he joined the Army Air Corps in 1917. He was the first to fly across the United States in less than 24 hours, first to fly the hazardous outside loop and first to take off, fly a set course and land without seeing the ground, thus pioneering the science of blind flying. During World War II, he led the first flight on Tokyo in 1942, and later served as commanding general of the Twelfth Air Force in North Africa, the Fifteenth Air Force in Italy, the Eighth Air Force in England and the Eighth Air Force on Okinawa.

Gen. J. H. Doolittle

James P. Ryan of the Midland, Texas, office of **Kerr-McGee Oil Industries, Inc.,** is now division landman at Denver. He is assisted by **Richard A. Hagg,** staff geologist. **J. L. Slater,** exploration manager of the **Braden Drilling Co.,** has resigned to become a consulting geologist at Denver.

Ashmun & Hilliard, No. 3 Ltd. of Midland, Texas, announce the association of **John F. Partridge, Jr.,** consulting geologist of Casper, Wyo., in opening an office in Casper for exploration activities in the Rocky Mountain area. Partridge is a former district exploration superintendent of The California Company.

E. B. Wasson

R. R. Berg

E. B. Wasson and **R. R. Berg** have recently formed the **Embar Oil Company** to carry on an exploration program in the Rocky Mountain states. Wasson was formerly with **Cosden Petroleum Corporation** as Rocky Mountain division manager in Denver and Berg was Cosden's division geologist. Embar will maintain offices in the Denver Club Building. The company will operate its own exploratory program during 1959, primarily in Wyoming. Embar also will handle Cosden's interests in the Rocky Mountain states on a contract basis.

Edwin A. Ritz of the **Clark Oil & Refining Corporation** has been appointed the Milwaukee, Wis., marketing regional manager.

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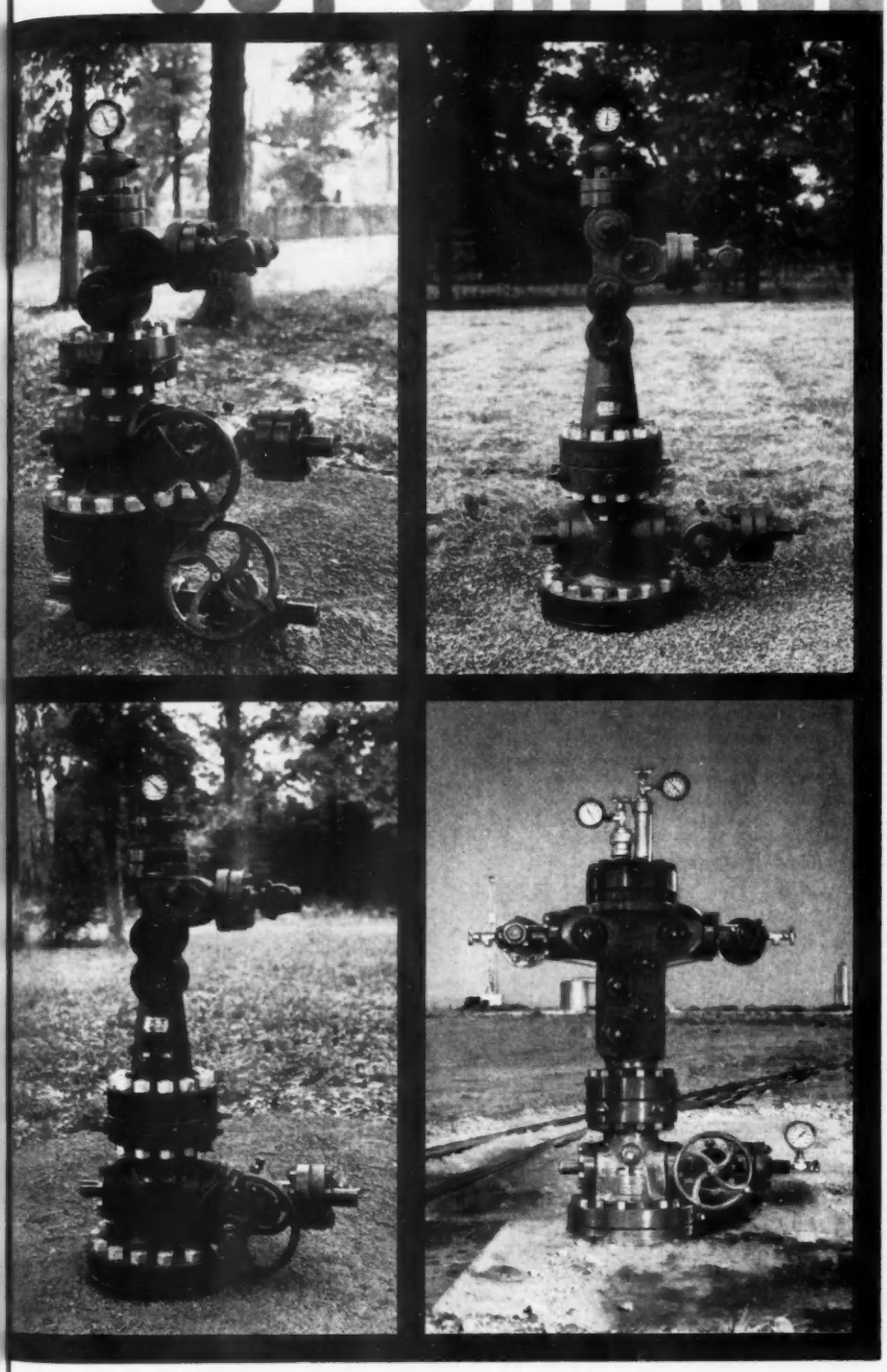

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Address Export Inquiries for All Countries to P. O. Box 3091, Houston, Texas.

Formerly manager of the Green Bay, Wis., district and previous to that, the St. Paul, Minn., district, Ritz becomes the company's fourth regional manager. He will be responsible for sales and operations in the St. Louis, Kansas City and Des Moines, Iowa, districts. He will report to **R. G. Atkinson,** recently elected marketing vice president.

R. A. Pryde

Ralph Brown

Robert A. Pryde has been appointed drilling superintendent of the **R. L. Manning Company, Oilwell Drilling Contractors.** During the past eight years, Pryde has acted as driller and toolpusher. To assist with operations, **Ralph Brown** has been appointed assistant drilling superintendent.

Preston E. Chaney has been named associate director of production research and development for **Sun Oil Company.** He will continue to make his headquarters at Sun's production research and development laboratory at Richardson, Texas.

P. E. Chaney

Arthur J. Heiser

Arthur J. Heiser, formerly vice president, has been appointed president of **Brown Drilling Company,** Long Beach, Calif., and of **International Brown Drilling Company.** The announcement was made recently by the board of directors of the two firms.

Kenneth T. McCamman has been named manager of **Shell Oil Company's** Coastal Production division. McCamman has been manager of Shell's San Joaquin production division since April, 1957. His successor in Bakersfield, Calif., has not been announced.

Los Angeles NOMADS Induct New Members

New members inducted at the December meeting of the Los Angeles Chapter of Nomads are here shown between Walter Ennis of Walter Ennis Company, assistant ritual master, (left) and Ole Olson of Southwestern Engineering Company, ritual master, (right). From left to right, Karl Mercer of Servco Corporation, associate; Ralph Huffines of Reed Roller Bit Company, associate; Ed Embury of The Guiberson Corporation, associate; Bob Noh, recently returned from Venezuela, regular; Bill Goertz of Monarch Engineering Corporation, regular.

E. L. Decker Elected Honorary NOMADS Regent

E. L. Decker, president of the Martin-Decker Corporation, Long Beach, Calif., one of the founders of the NOMADS in 1938, has been elected to the post of an honorary regent, to act as advisor and consultant to the national board of regents.

St. Louis Desk and Derrick Elects Mrs. Steinmeyer

The Desk and Derrick Club of St. Louis, recently elected Mrs. Anne Steinmeyer, Petrolite Corporation, president for the coming year. She succeeds Miss Sydney Dickerson, Clark Oil and Refining Company.

Other officers chosen in the St. Louis Chapter were: Vice President, Miss Mary Louise Hyde (W. C. McBride, Inc.); Secretary, Miss Katherine Royal (Sohio Petroleum Company); Treasurer; Miss Maria Blakney (Sohio Petroleum Company); Directors, Miss Lucille Henneke (Sohio Petroleum Company) and Mrs. Lee Mohler (Petrolite Corporation).

Miss Paula Mace, of Mt. Vernon, Ill., and director of Region Two of the Desk and Derrick Clubs of America, installed the new officers at the Club's annual Christmas party last December 11, in St. Louis.

Y'all Come

NOMAD representatives examine an engraved invitation to the International Petroleum Exposition which is being held in Tulsa, May 14-23. NOMADS in the Houston, Dallas-Fort Worth, Los Angeles, New York and Tulsa chapters will send the invitations to their customers. Looking over the special invitation are Tulsa NOMADS, R. C. Glover (left) of Baker Oil Tools and H. M. Cooley, Bethlehem Supply Company, and Don Collins, Republic Supply Company, chairman of the NOMADS Committee for the IPE.

Houston Chapter NOMADS Elect Officers for 1959

The above Nomads were elected to fill the offices of the Houston Chapter for 1959 at the December meeting of the organization. Left to right: Jas. B. Hughes, national senior regent; B. J. Gross, assistant secretary; F. S. Mims, treasurer; J. C. Woods, sergeant-at-arms; J. B. Jones, secretary; B. H. Pickard, president; John W. Gates, vice president; A. C. Oden, deputy sergeant-at-arms; E. W. Louden, immediate past president and national junior regent. Bruce Barkis, assistant treasurer, was not present for the picture. These new officers were officially inducted at the annual inaugural dinner-dance at the Shamrock Hilton Jan. 17.

WHO'S MEETING WHERE

1959 FEB.	
1-4	AAPG, Rocky Mountain Section, Civic Auditorium, Albuquerque, New Mexico.
1-6	AIEE, Statler, Sheraton & McAlpin Hotels, New York.
2-27	Southwestern Legal Foundation, Short Course on Oil and Gas Law, Southwestern Legal Center, Dallas.
11-12 -13	NACE, Tulsa Section, Tenth Annual Pipe Line Corrosion Short Course, Mayo Hotel, Tulsa, Okla.
11-13	Southwestern Legal Foundation, 10th Annual Institute on the Law of Oil, Gas and Taxation, Southwestern Legal Center, Dallas.
15-19	AIME, Annual Meeting, St. Francis, Sheraton-Palace and Sir Francis Drake Hotels, San Francisco.
24-25	Geological Symposium, The University of Oklahoma, Norman, Okla.
26-27	API, Division of Marketing, Lubrication Committee Meeting, Sheraton-Cadillac Hotel, Detroit.
MAR. 4- 6	API Division of Production, Southwestern District, Scharbauer Hotel, Midland, Texas.
16-19	AAPG, 44th Annual Meeting, Statler Hilton, Dallas.
17-21	NACE, National Meeting, Civic Auditorium, San Francisco.
19-20	SAE, National Production Meeting, Sheraton-Cadillac Hotel, Detroit.
25-27	API Division of Production, Southern District, Roosevelt Hotel, New Orleans.
31- Apr. 2	Power Conference, Illinois Institute of Technology, 21st American Power Conference, Hotel Sherman, Chicago.
APRIL 5- 9	Nuclear Congress, Engineers Joint Council, Cleveland, Ohio.
8-10	API Division of Production, Eastern District, Spring Semi-Annual Meeting, Penn-Sheraton Hotel, Pittsburgh, Penn.
20-24	Petroleum & Chemical Industry Short Courses, Safety Engineering, University Downtown Center, Lockett Hotel, the University of Oklahoma, Norman, Oklahoma.
22-24	API Mid-Continent District Meeting, Herring Hotel, Amarillo, Texas.
26-28	TIPRO, 14th Annual Meeting, Baker Hotel, Dallas.
27-28	Petroleum & Chemical Industry Short Courses, Automatic Control, Oklahoma Memorial Union Building, University of Oklahoma, Norman, Okla.
27-28	SEG, 12th Annual Midwestern Exploration Meeting, Cortez Hotel, El Paso, Texas
30- May 1	API Division of Production, Pacific Coast District, Biltmore Hotel, Los Angeles.

Nomads' Chapter monthly meeting: Los Angeles, second Wednesday, Jonathan Club, Wallace A. Sawdon, Secretary. Houston, second Monday, Ye Old College Inn, Harry E. Estes, Secretary. Dallas-Fort Worth, first Monday, Greater Dallas Club, Hank Davis, Secretary. Tulsa, Hotel Tulsa, Gilbert Swift, Secretary. New York, first Monday, Hotel Biltmore, Jesse E. Hickman, Secretary.

What's Happening among SERVICE and SUPPLY MEN

W. F. Barstow

E. C. Broun, Jr.

E. C. (Ned) Broun, Jr., has been appointed general sales manager and **W. F. Barstow** has been appointed industrial sales manager for **Southwest Industries, Inc.**, it has been announced. Broun, who heads up the company's expanded sales campaign, prior to joining Southwest Industries, was vice president of the Henderson Drilling Corp., chief petroleum engineer for Highland Oil Company and petroleum engineer for Humble Oil & Refining Company. Barstow was formerly connected with Minneapolis-Honeywell Corporation, Standard Oil Company of Indiana and Gas Atmospheres, Inc., of Cleveland, Ohio. Carl J. Maki, who was elected president of the Canadian subsidiary, Southwest-Barber, Ltd., will head the new Canadian office and Charles E. Richards, Jr., has been appointed sales engineer in charge of small horsepower packaged compressors.

The Albuquerque Nuclear Division of **The Kaman Aircraft Corporation** announces the appointment to its Senior Research Staff of **Frank B. Gray, Jr.**, who pioneered the use of the new spectrometric techniques (infrared and chromatography) in chemical well logging. In his new position, he will be responsible for the introduction of the first commercially available down-hole accelerator tube—a Kaman development—to the neutron logging field. Production of this electronic tube will be shifted to Colorado Springs early next summer, when the Nuclear Division moves to its new offices and laboratory facility now under construction at this site. Gray has held supervisory positions with Geophysical Service Incorporated, Leeds and Northrup Company, Petroleum Service and Research Corporation, and Caran Engineering.

Frank B. Gray, Jr.

Chicago Pneumatic Oil Tool Company of Fort Worth have announced the addition of new members to the Houston office which enlarges that branch office's operations. **Herb Tefertiller** is the district manager; **Warner Abel** is the new field engineer; **Albert Bateson** is the new Houston sales representative; **C. H. Chapman** will handle the sale for Liberty, Texas, and **Dave Carroll** is in charge of sales in Victoria, Texas. The new additions for the company were effective January 1.

Texas Instruments Incorporated has announced the following officers elections: **Cecil Dotson**, of Dallas, was elected chairman of the board of directors of **Texas Instruments Limited**, wholly-owned British subsidiary of the Texas Instrument Co. Texas Limited has headquarters and manufacturing facilities at Bedford, England. Dotson succeeds **P. E. Haggerty** in the British company's board chairmanship. He assumed his new position on January 1. A key divisional executive of the parent company in Dallas, he currently is manager of operations at TI's Semiconductor-Components division with responsibility for the division's six product departments—silicon products, germanium products, diodes and rectifiers, special germanium devices, resistors, and capacitors. **Dudley Saward**, managing director of Texas Instruments Limited, will continue in that position and report to Dotson. **E. O. Vetter**, general manager of the Industrial Instrumentation division with headquarters at the division's plant in Houston, has been elected as assistant vice president of the parent company, Texas Instrument Incorporated. His election was effective immediately and will continue to headquarter in Houston.

E. O. Vetter

Berwin L. Price

Charles E. Wright

Berwin L. Price and **Charles E. Wright, Ideco**, technical service representatives, have been assigned to new territories. Price has been transferred from the Gulf Coast area to Tulsa. His territory will include Oklahoma, Kansas and neighboring states. Before going to Tulsa, Price was the Ideco area representative covering southeastern Texas, Louisiana and Mississippi. Since joining Ideco in 1952, Price has worked in the proposal department

and in the export sales department. Wright has been assigned to cover the territory previously handled by Price. He will make his headquarters at Ideco's Beaumont plant. He has been with Ideco since 1953 and was manager, pricing and specifications, at the Beaumont plant until his recent appointment.

Carl Brown

Ralph Fanthus

Carl Brown has been transferred from Los Angeles to Denver where he will set up new headquarters for **Kobe, Incorporated's** Rocky Mountain sales division. **Ralph Fanthus,** district sales manager, has been moved from Bakersfield, Calif. to Los Angeles and will have charge of California sales activity.

Davey, Paxman & Co., Ltd., of Colchester, England, manufacturers of diesel engines, have appointed **Federal Equipment Western Limited,** Alberta, Canada as their Canadian agents for diesel sales and services.

Peter W. Cooke, recently appointed manager of the newly created **Magcobar Division of Dresser (Great Britain) Limited,** will be responsible for that company's activities in Europe and the Middle East, it has been announced. Prior to his appointment as manager of the Magcobar Division of Dresser (Great Britain) Limited, Cooke served on the London headquarters staff of British Petroleum Co., as senior chemist responsible for the mud operations of the company's widespread drilling activities. He served in this position four years, traveling extensively in Europe, the Persian Gulf area, and Papua to assist in the solution of drilling mud problems. Magcobar's new representative will make his headquarters in Dresser's offices in London.

Peter W. Cooke

Southern Pipe, Azusa, Calif., a division of **U. S. Industries, Inc.,** announced the appointment of **W. F. Dickinson** as sales specialist for Southern's new range of API approved, lightweight steel pipe to the oil and gas industries, according to a recent announcement. Dickinson represented the Fabricated Steel Division of U.S. Steel on the west coast for 22 years before joining Southern Pipe.

W. F. Dickinson

T. P. Tarwater

R. C. Holden

T. P. Tarwater has been elected vice president and **R. C. Holden** and **W. S. Jones** have been promoted to key positions by **Mid-Continent Supply Co.,** Fort Worth, according to a recent announcement. In his new position, Tarwater will be in charge of Mid-Continent sales operations in West Texas, New Mexico and the Rocky Mountain areas. Holden is now assistant division manager of Mid-Continent Supply Company's Tulsa Division. Jones was promoted from assistant manager of the Used Equipment Department to manager of that department.

W. S. Jones

H. E. Arnold has been promoted to local representative in Tulsa for **Bethlehem Supply Company.** He will be responsible for direct sales contacts with oil companies and contractors in the area. Replacing Arnold is **S. G. Roegels,** formerly store manager at Abilene, Texas. **R. E. Ligon,** formerly store manager at Sweetwater, Texas, has been transferred to Abilene in the same capacity.

Houston Oil Field Equipment has announced the promotion of **J. W. (Mutt) Caskey, Jr.,** from division sales manager to western sales representative. Caskey will cover the western half of the United States with the exception of the Gulf Coast. He has been with HOMCO for 18 years, the last six years have been in the mountain states.

J. W. Caskey, Jr.

W. L. Hunter

W. L. (Luke) Hunter, who has been manager of **Hughes Tool Company's** northern region, which until recently extended from Oklahoma to and including all of Canada, for the past 12 years, has been reassigned, it has been announced. In his new assignment, Hunter is special representative for Hughes Tool Company with headquarters in Oklahoma City.

Philip Lipschultz has been named to **Shell Oil Company's** newly created head office post of manager of commodity-supply and statistics. He will be responsible for supplying head office and field purchasing-stores departments with data on costs and availability of materials and equipment. Lipschultz was formerly manager of the company's Houston purchasing department. He joined Shell in 1920 in the company's San Francisco purchasing department. He has served as assistant department manager of the Los Angeles office and manager of purchasing and stores of the San Francisco office. He was named manager of the Houston department in 1951.

H. Robert Baer has been appointed sales representative in the northeastern Ohio and northwestern Pennsylvania territory for **Leschen Wire Rope Division, H. K. Porter Company, Inc.** according to a recent announcement.

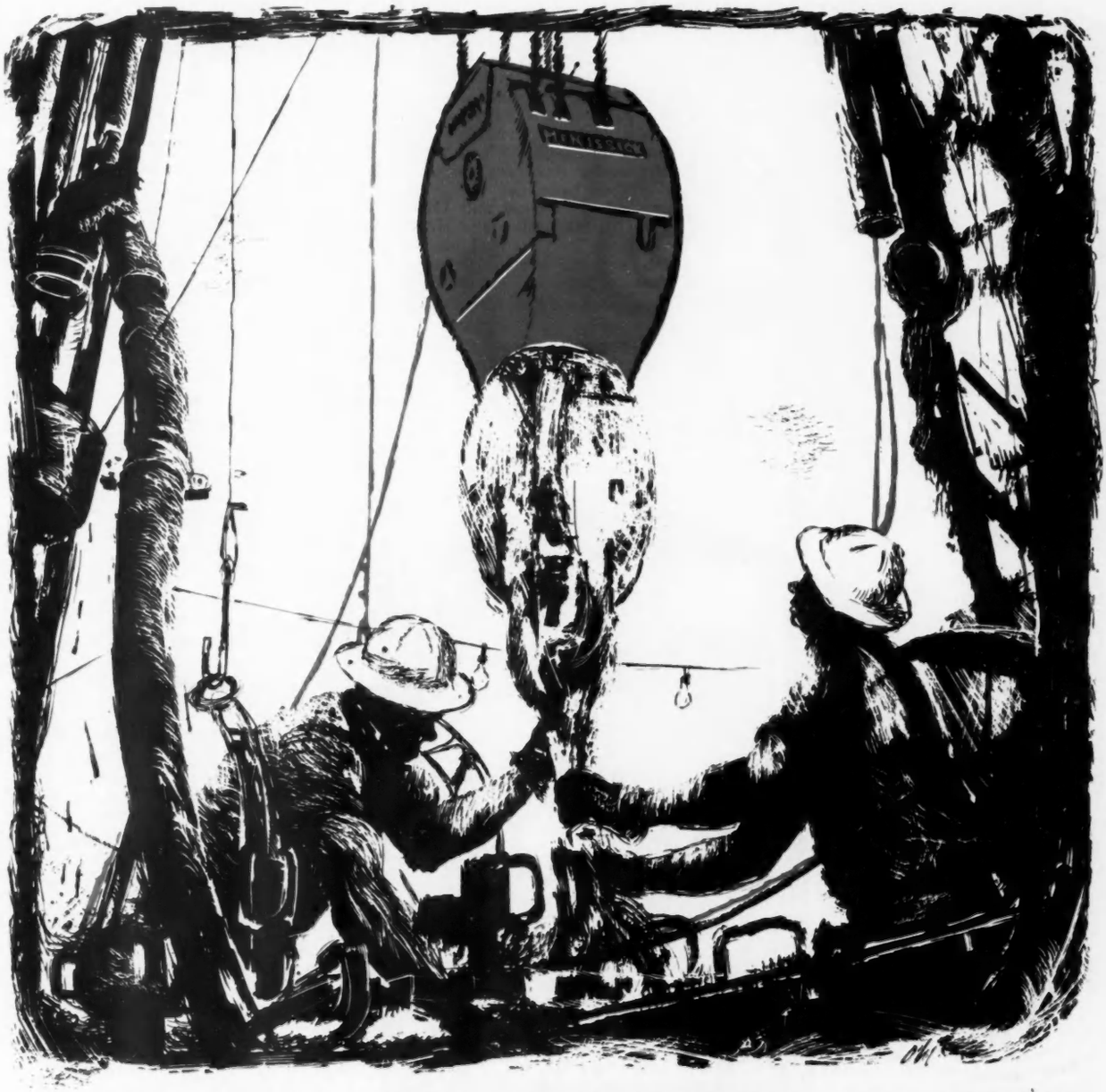
John L. Tullis has been elevated to president and general manager of **The J. B. Beaird Company, Inc.,** a subsidiary of **American Machine & Foundry Company.** Tullis, who has been executive vice president, succeeds **J. Pat Beaird,** who resigned on December 31. Beaird will remain as a director of the Beaird Company and a member of the board of directors of the American Machine & Foundry Company. In addition to assuming the presidency of The J. B. Beaird Company, Inc., Tullis will also head Beaird International, Inc., and the Phoenix Corporation. Tullis entered the company in 1947 as general manager of sales and was advanced to vice president of sales in 1954. In July, 1957, he was appointed executive vice president of the company and a member of its board of directors.

John L. Tullis

W. S. Jacobsen has been promoted to the position of general sales manager of **Fred E. Cooper, Inc.,** it has been announced. Jacobsen joined the Fred E. Cooper organization as a Texas Gulf Coast representative in Houston, in 1953. He is an active member of the API and the Association of Oilwell Servicing Contractors. His oil field equipment experience sales experience has been in the fields of Oklahoma, New Mexico, Louisiana and Texas.

W. S. Jacobsen

The National Supply Company has opened an oil field supply store at Summersville, Green County, Ky. The location is in south central Kentucky, about 60 miles southeast of Louisville. **Viril L. Cunningham,** formerly manager of the company's store at Fairfield, Ill., has been appointed manager. The Summersville store is under the jurisdiction of **Robert T. Harris,** manager of the Illinois district.



WHATEVER YOUR REQUIREMENTS—BE SPECIFIC

GET McKISSICK

THE BEST BLOCK FOR YOUR PURPOSE

Double row pre-adjusted Timken bearings.

Alloy steel flame hardened sheaves, grooved to proper line size.

Extra weight for free non-wobbling falls.

Heavy center or divider plates between each sheave, more evenly distribute heaviest loadings, and eliminate center pin deflection.

Johns-Manville "Klipper" grease seals positively retain lubricant, exclude all foreign matter from bearing cavity.

E-Z* opening guards for quick stringing up—no bolts to pull out and lose.

McKISSICK

McKISSICK PRODUCTS CORPORATION
Box 2496 Tulsa, Oklahoma

Curt T. Pearson

William B. Colvin

Curt T. Pearson, formerly assistant sales manager of **Texsteam Corporation,** Houston, has been appointed sales manager of the heater and steam generator division. **William B. Colvin,** has been appointed sales manager of the pump and valve division.

John Staudt, executive vice president and director of the **Dowell Division** of **The Dow Chemical Company,** is the president of the newly-organized **Dowell Division of Dow Chemical International Limited, S. A.** Other officers are: **A. C. Polk** and **L. B. Swan,** vice presidents; **Tromer R. Smith,** general manager; **Neil Miller,** treaturer; and **J. H. Hanes,** secretary. Directors of the new division are the above named officers, and **A. P. Beutel** and **Oliver E. Beutel.** Staudt, Polk, Miller and Hanes are with Dowell in Tulsa, Oklahoma; Swan and Smith will be located in the new Dowell foreign headquarters in Houston. A. P. Beutel, also a Dow Chemical director, has his office at Freeport, Texas, where he is general manager of the Texas division of Dow. He is also president of Dowell. Oliver E. Beutel is located at the Midland, Mich., headquarters of Dow Chemical.

H. G. Smith

L. F. Smith

The **A. O. Smith Corporation,** Milwaukee, Wis., recently announced the acquisition of the **Erie Meter System, Inc.,** Erie, Penn. **H. G. Smith,** manager of Smith's meter, service station pump, divisions, will serve as president and general manager of the Erie firm. **L. F. Smith,** executive vice president of Erie will manage the Pennsylvania plant operation. **F. S. Cornell** is the executive vice president of A. O. Smith Corporation. **W. B. Johnson,** sales vice president of Erie, will serve as staff assistant to H. G. Smith. **H. D. Leisenring,** general manager of Smith's meter, service station pump, divisions, has been named as the general sales manager of the new organization. **John Thompson** sales manager of Erie, is the assistant sales manager of the newly integrated sales group. **Marven Sorg** will continue in charge of A. O. Smith's Los Angeles plant operations.

Over 100 Representatives At Layne & Bowler Meeting

More than 100 representatives of Layne associate companies in the United States and Canada attended the 24th annual Layne meeting in Memphis, Tenn., recently, sponsored by Layne & Bowler, Inc.

W. H. Reeves, president of Layne & Bowler, Inc., was in charge of the three-day session, which was held at the Peabody Hotel.

Four new Layne executives, all of whom are now residents in Memphis, were introduced by E. J. Rogers of Layne-Northwest Company, Milwaukee, chairman of the board of Layne & Bowler, Inc. They were C. E. Ponkey, executive vice president; Edward Rudnicki, chief engineer; T. H. Clark, Jr., sales manager; and Paul Schulz, factory manager.

Opening session of the meeting was conducted by the Layne Research division of Layne & Bowler, Inc. Other panel discussions were on pump sales, water well drilling, water and sewage treatment and water research.

The annual Layne banquet, which was held in the Venetian room at the Peabody, was a highlight of the opening day's program. Final session was a water treatment instruction period by General Filter Company of Ames, Iowa, a Layne & Bowler, Inc., affiliate.

Larkin Packer Company Opens New Canadian Warehouse

The Larkin Packer Company opened a new warehouse recently in Edmonton, Alberta, Canada.

Larkin's warehousing and sales activities in Canada will be operated as a separate Canadian subsidiary wholly owned by the parent company. The subsidiary will do business under the same name of Larkin Products Ltd.

Representing Larkin Products Ltd., as sales representatives in Canada are Lloyd Helmer in Calgary and Don Wilson in Edmonton. Both men have been covering this territory for a number of years.

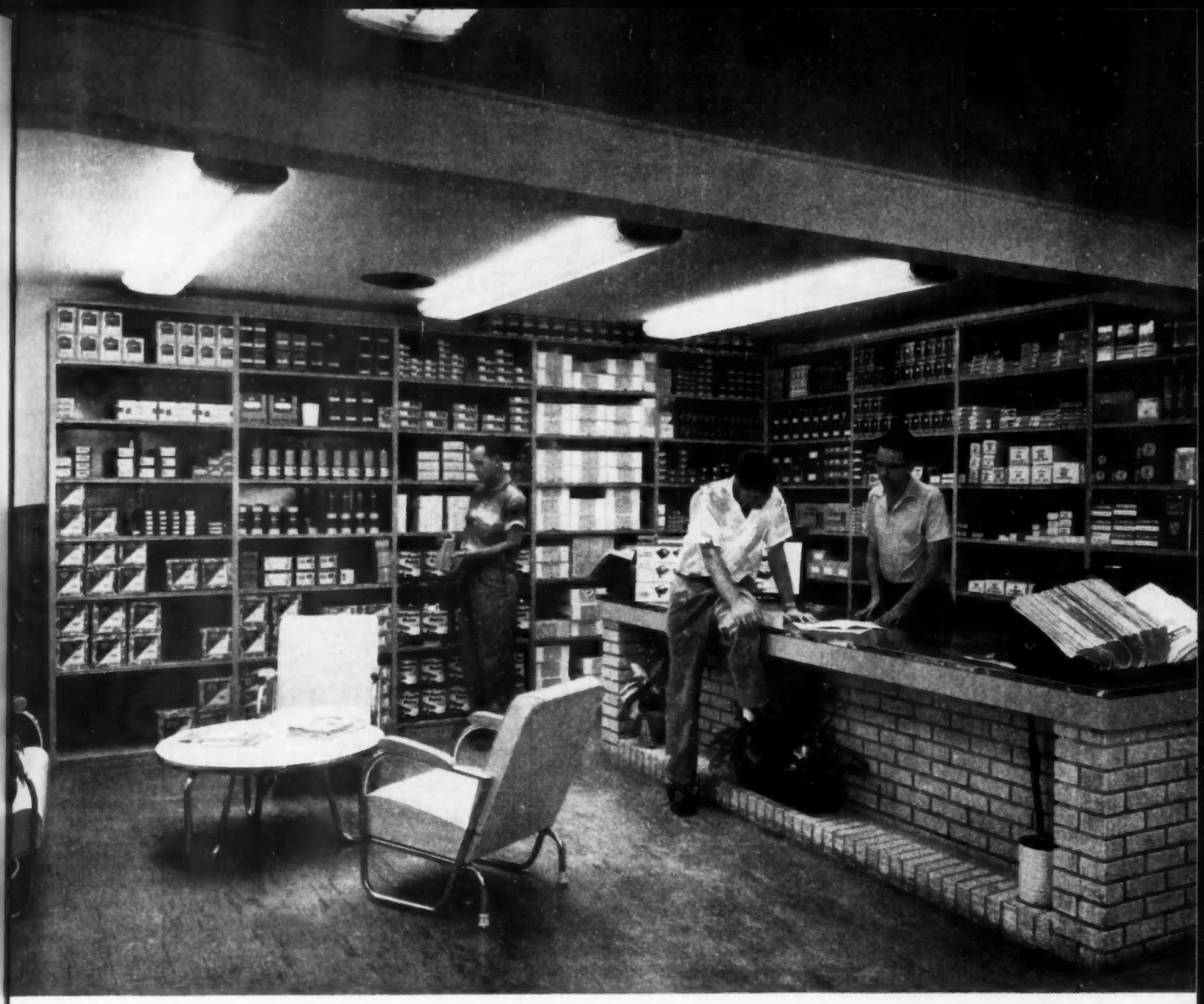
You'll win more than this prize. You'll increase drilling efficiency and control your mud better. Mud-O-Graf records every variation in mud weight, saving time and costly errors in the addition of weighting materials. All heavy and light streaks in the circulating system and their duration are recorded. Mud-O-Graf shows how often the hole is filled up when coming out of the hole and shows the time of a complete circulation. If it's a question of mud, ask for Mud-O-Graf.

WARREN AUTOMATIC TOOL CO. WATCO HOUSTON

WARREN AUTOMATIC TOOL CO.

Manufacturers of Pit-O-Graf and Rig Runner.

3915 Tharp St.	Houston	CApitol 4-2511
Lake Charles, La.	New Iberia, La.	Harvey, La.
HEmlock 6-2265	EMerson 9-9862	FOrest 6-1441



At our Bethlehem stores, nothing is quite so important as pleasing the customer. We try to anticipate his preferences, his choice of brands, his buying habits. We strive to be ready when he's under pressure and requires extra service.

Often he hurries into the store and wants his order put together in nothing flat. We can usually accommodate him. Bethlehem stores are geared for emergency demands. But when he can take his time, and decides he needs a breather, we do our best to make him feel at home.

Bethlehem now has 55 stores in 13 states and Canada. All stock brands of merchandise you've known for years. But the stores have something else in common—friendly, personal service, no matter how small the customer's needs. Sound like something you've been looking for?

BETHLEHEM STEEL COMPANY
Supply Division
General Offices: 21 E. Second St., Tulsa, Okla.

West Coast: BETHLEHEM PACIFIC COAST STEEL CORPORATION
Supply Division
Los Angeles, Calif.

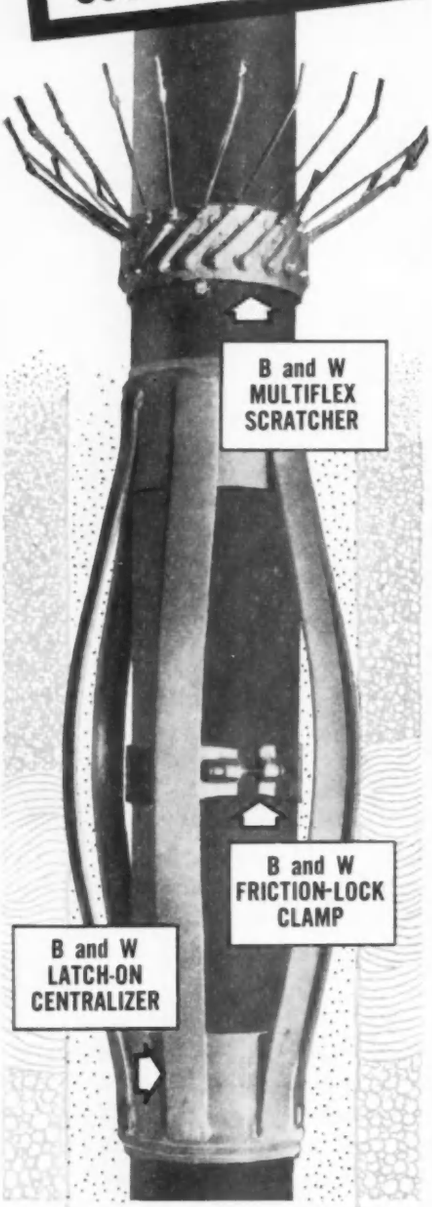
Canadian Distributor:
Bethlehem Supply Company of Canada, Ltd.
Calgary, Alberta, Canada

Export Distributor:
Bethlehem Steel Export Corporation
25 Broadway, New York, N. Y.

BETHLEHEM STEEL
SUPPLY DIVISION

B and W

A Good Combination for a GOOD CEMENT JOB



OTHER PRIMARY CEMENTING TOOLS: Hinged Nu-Coil Scratchers • Rotating Scratchers, Multi-Flex and Nu-Coil Types • Automatic Stop Collars • Stabilizers • Rotator Collars • Liner Centralizers.

B and W Inc.

Well Completion Specialists

GULF COAST
Box 5266
Houston 12, Texas
Phone WA 3-6603

WEST COAST
19706 S. Normandie Ave.
Torrance, California
Phone FAculty 1-2463

"I'll break it to you slow—
S-A-L-T-W-A-T-E-R."

WORLD OIL

Birds and Bees

"Where did I come from, Daddy?" asked the small boy. The youngster listened attentively to the long explanation. At the end, his father said, "What made you ask, son?"

"Oh, nothing special, Daddy, except I heard a new boy at school say he came from Chicago and wondered where I came from."

•

Protection

A man walked into the village grocery store and furtively asked to buy all overripe vegetables and aged eggs. The clerk eyed him with a twinkle and declared:

"You must be going to the theatre tonight to see that new comedian."

"Sh-h-not so loud," whispered the man. "I AM that new comedian."

•

No TV on TV

Although they are usually composed of stupid husbands, smug wives and illmannered children, there is one thing admirable about the families in the TV serials—they don't waste their time watching TV.

•

Turncoat

There came a frantic ring over the phone at police headquarters, and a wild voice said, "There's a burglar in Miss Spinster's bedroom at Number 8490 Blank Street. Send the police at once, for heaven's sake!'

"All right," answered the sergeant. "Is this Miss Spinster speaking?"

"No," came back the anguished voice, "this is the burglar."

•

Knotheads

The sergeant was explaining the new ammunition to a bunch of recruits like this:

"This type of bullet will penetrate two feet of solid wood. So remember to keep your heads down."

Infidelity

Poppa Robin: "How did that speckled egg get into our nest?"

Momma Robin: "I did it for a lark."

•

Touch and Go

Then there was the college kid who was learning to use a typewriter so that when he wrote home for money he could use the touch system.

•

Historic Conference

Two inmates were talking: "I've made up my mind," blurted one suddenly. "Tomorrow I order my legions to invade England. History will never say that Julius Caesar faltered in pursuing the Britannic campaigns."

"England, eh?" mused the other. "Well, Julius, if I were you . . . and, incidentally, I am . . . "

•

Facts of Life

A woman who makes a match for her daughter sometimes intends to referee it as well.

•

Dubious Service

"I ordered a dozen oranges but you only sent me 10."

"Part of our service, ma'am. Two were bad so we save you the trouble of throwing them away."

•

Cold Facts

The reason that it's called "cold cash,"
I ruefully submit:
We never have it long enough
To warm it up a bit.

•

Unwilling Salesman

She: "Did you ever try selling vacuum cleaners?"

He: "I should say not."

"She: "Well, you'd better start trying; that's my husband coming up the walk."

•

How True!

"How much sleep do you ordinarily require?" asked the doctor.

"About five minutes more."

SECONDARY RECOVERY
Since 1922

PETROLEUM ENGINEERS
CABLE & STEPHENS
WICHITA FALLS, TEXAS

RESERVOIR ENGINEERING
Water Flooding Gas Repressuring
EVALUATION CORE ANALYSIS
SURVEYS ECONOMICS
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FIELD SUPERVISION
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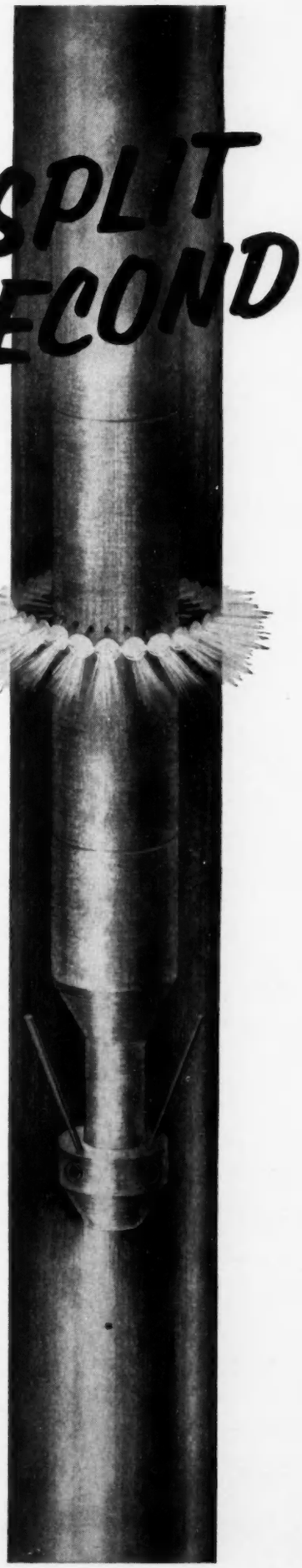
Cuts tubing in a SPLIT SECOND



CHEMICAL CUTTER RECOVERS 13,788′ OF TUBING

This oil well was a dual completion with two strings of tubing inside 7″ OD casing. Operator was unable to pull 2″ tubing. McCullough Magna-Tector (Free Point Finder) was run—found packer stuck at 13,899′. An unsuccessful attempt was made to jar the packer loose with a String Shot.

McCullough Chemical Tubing Cutter was then run to 13,788′, cut was made and tubing removed from the hole. All wire line operations were completed in nine hours rig time in spite of severe complications—extreme depth, tubing restricted by choke valves, and 800 lbs. pressure on tubing during operations.

McCullough®

CHEMICAL TUBING CUTTER

Here's a "split-second" tubing cutter that will save more than 80% of the rig time usually required to cut tubing by mechanical methods. It is an electric wire line tool which applies the enormous power of the halogen fluorides to cut through tubing quick as a wink.

McCullough's Chemical Cutter makes a clean, flare-free cut—no burrs nor distortion on either the OD or ID of the tubing. Cutting operation is junk free, since no part of the cutter is expendable. It will not damage casing even though the tubing be as close as 1/64″.

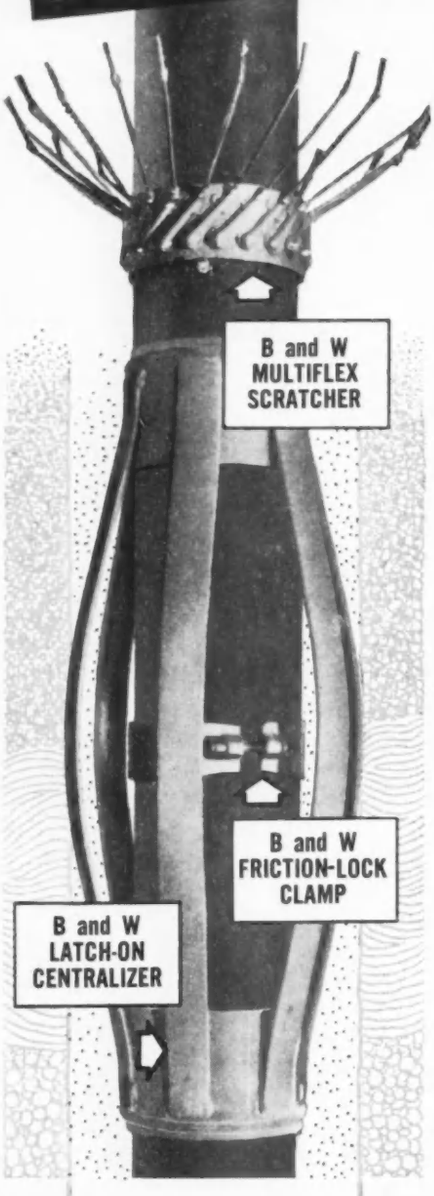
Ask your McCullough Service Engineer about this revolutionary new service. Available for 2″ or 2-1/2″ tubing at all McCullough Service Locations.

McCullough
TOOL COMPANY
Service ANYWHERE ANYTIME

LOS ANGELES
HOUSTON
EDMONTON
Over 70 Oilfield Service Branches
Cable Address: MACTOOL

Additional Service Representative: Houston Oil Field Material Company, Inc.

B and W
A Good Combination for a GOOD CEMENT JOB



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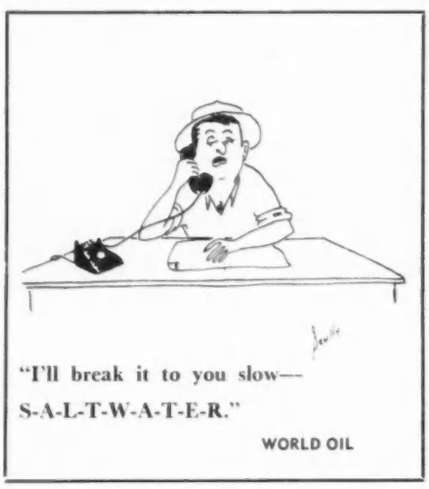
SQUEAKS from the BULLWHEEL



"I'll break it to you slow—
S-A-L-T-W-A-T-E-R."

WORLD OIL

Birds and Bees

"Where did I come from, Daddy?" asked the small boy. The youngster listened attentively to the long explanation. At the end, his father said, "What made you ask, son?"

"Oh, nothing special, Daddy, except I heard a new boy at school say he came from Chicago and wondered where I came from."

•

Protection

A man walked into the village grocery store and furtively asked to buy all overripe vegetables and aged eggs. The clerk eyed him with a twinkle and declared:

"You must be going to the theatre tonight to see that new comedian."

"Sh-h-not so loud," whispered the man. "I AM that new comedian."

•

No TV on TV

Although they are usually composed of stupid husbands, smug wives and illmannered children, there is one thing admirable about the families in the TV serials—they don't waste their time watching TV.

•

Turncoat

There came a frantic ring over the phone at police headquarters, and a wild voice said, "There's a burglar in Miss Spinster's bedroom at Number 8490 Blank Street. Send the police at once, for heaven's sake!'

"All right," answered the sergeant. "Is this Miss Spinster speaking?"

"No," came back the anguished voice, "this is the burglar."

•

Knotheads

The sergeant was explaining the new ammunition to a bunch of recruits like this:

"This type of bullet will penetrate two feet of solid wood. So remember to keep your heads down."

Infidelity

Poppa Robin: "How did that speckled egg get into our nest?"

Momma Robin: "I did it for a lark."

•

Touch and Go

Then there was the college kid who was learning to use a typewriter so that when he wrote home for money he could use the touch system.

•

Historic Conference

Two inmates were talking: "I've made up my mind," blurted one suddenly. "Tomorrow I order my legions to invade England. History will never say that Julius Caesar faltered in pursuing the Britannic campaigns."

"England, eh?" mused the other. "Well, Julius, if I were you . . . and, incidentally, I am . . . "

•

Facts of Life

A woman who makes a match for her daughter sometimes intends to referee it as well.

•

Dubious Service

"I ordered a dozen oranges but you only sent me 10."

"Part of our service, ma'am. Two were bad so we save you the trouble of throwing them away."

•

Cold Facts

The reason that it's called "cold cash,"
I ruefully submit:
We never have it long enough
To warm it up a bit.

•

Unwilling Salesman

She: "Did you ever try selling vacuum cleaners?"

He: "I should say not."

"She: "Well, you'd better start trying; that's my husband coming up the walk."

•

How True!

"How much sleep do you ordinarily require?" asked the doctor.

"About five minutes more."

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Since 1922

PETROLEUM ENGINEERS
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Water Flooding Gas Repressuring
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Cuts tubing in a SPLIT SECOND

CHEMICAL CUTTER RECOVERS 13,788′ OF TUBING

This oil well was a dual completion with two strings of tubing inside 7″ OD casing. Operator was unable to pull 2″ tubing. McCullough Magna-Tector (Free Point Finder) was run—found packer stuck at 13,899′. An unsuccessful attempt was made to jar the packer loose with a String Shot.

McCullough Chemical Tubing Cutter was then run to 13,788′, cut was made and tubing removed from the hole. All wire line operations were completed in nine hours rig time in spite of severe complications—extreme depth, tubing restricted by choke valves, and 800 lbs. pressure on tubing during operations.

McCullough®

CHEMICAL TUBING CUTTER

Here's a "split-second" tubing cutter that will save more than 80% of the rig time usually required to cut tubing by mechanical methods. It is an electric wire line tool which applies the enormous power of the halogen fluorides to cut through tubing quick as a wink.

McCullough's Chemical Cutter makes a clean, flare-free cut—no burrs nor distortion on either the OD or ID of the tubing. Cutting operation is junk free, since no part of the cutter is expendable. It will not damage casing even though the tubing be as close as 1/64″.

Ask your McCullough Service Engineer about this revolutionary new service. Available for 2″ or 2-1/2″ tubing at all McCullough Service Locations.

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Service ANYWHERE ANYTIME

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To get your copy, address your order to: Librarian, Gulf Publishing Company, Post Office Box 2608, Houston 1, Texas. Or if you prefer, you can use the convenient Readers' Service Blue Postcard just inside the back cover of this and every issue of WORLD OIL. Just check the square indicated, fill in your name and address and drop the postpaid card in the mail. The annual WORLD OIL Editorial Index will be sent you by return mail. Do it now. The supply is limited.

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RATES: Regular Classified (undisplayed) set in this size type: 20 cents per word. Minimum charge $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border, $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All classified ads payable in advance.** Send copy and checks to: Trading Post Classified Section, World Oil, P. O. Box 2608, Houston, Texas.

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■ Incorporate in Nevada—Do business anywhere. Positively no liability of organizers, promoters or stockholders. Over 25 years experience. Financing assistance at no additional cost. Write for resume. Las Vegas Inc., Co., 721 S. 4th St., Las Vegas, Nevada.

■ Financial Contacts. Underwriters, Brokers, Private Finders of Capital reached. No shopping. Confidential. Free Enterprise Associates, 817 - 51st St., Brooklyn, N. Y.

We specialize in handling volume deals, merger, sale or purchase of Oil Corporations. Inquiries invited. George Moran, H. H. WATSON, REALTOR, Texas Bank Bldg., Dallas, Texas.

HELP WANTED

Wanted
Drilling Superintendent—
Petroleum Engineer

Experienced Drilling Superintendent, who is also fully qualified as a Petroleum Engineer, to supervise one-rig operation in Turkey. Top salary and bonus. Send complete history and references. Replies confidential. Box 182-W, WORLD OIL, Houston, Texas.

Wanted geophysicist by important European geophysical company. Location in Algiers. Job consists of establishing and maintaining contact with U. S. clients technically and commercially, and securing business. Applicant must have long field and office experience. Mail qualifications and experience to Box 183-W, WORLD OIL, Houston, Texas.

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1959
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16 pocket-size, plastic-bound personnel directories covering the entire oil industry of the world, from top executives to foremen. Over 110,000 key men are listed. First eight book cover Producing and Drilling Contracting.

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14. Directory of Geophysical and Oil Companies Who Use Geophysical Service
15. Directory of Oil Well Supply Companies (Covers the World)
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SITUATIONS WANTED

■ Exploration Geologist, 33, married, family, masters, desires relocation. 8 years experience; 5 rig supervision, well completions, workovers, 3 consulting. Prefer aggressive independent or investment group, advancement opportunity. Excellent references. Experienced all phases oil business. Box 181-W, WORLD OIL, Houston, Texas.

■ Production or work over foreman three years college, 27 years experience, 16 years in secondary recovery. Box 180-W, WORLD OIL, Houston 1, Texas.

■ Husband-wife teaching team desires overseas employment. Ages 28 & 26. One years experience. B.S. in social studies and speech education. Currently teaching: government, geography, history of civilization, current history, sociology, psychology, speech and drama, English, phonetic bases of speech. For clarification and information, contact Mr. & Mrs. John Sims, All Saints Episcopal Girls' School, Vicksburg, Mississippi.

FBI Hunts 'Dangerous' Suspect in Southwest

Herbert Shockey

Herbert Leroy Shockey, also known as Herbert Leroy Drost, Billy Lee Hunt, James B. Lynch, Billy Pete Pitman, Claude Sawyer, W. D. Sterling, Herbert Troop, Herbert Leroy Troop, Howard Dean Ward, and Jonny Weeks, is being sought by the FBI as a Federal Probation Violator and for the alleged interstate transportation of a stolen motor vehicle. He is believed to be employed as a "paraffin cutter" in an oil field in one of the southwestern or western states. On July 26, 1957, at Albuquerque, New Mexico, a Federal Probation Violator warrant was issued for the arrest of Herbert Leroy Shockey for violation of his Federal probation.

On October 31, 1957, a Federal grand jury at Denver indicted Herbert Leroy Shockey for violation of the U. S. Penal Code, Title 18, Section 2312, known as the Interstate Transportation of Stolen Motor Vehicle Act. This indictment charged that on or about July 6, 1957, Shockey transported in interstate commerce a 1956 Chevrolet four-door sedan from Eugene, Ore., to Denver, knowing it to have been stolen.

Shockey has a criminal record dating from 1950 which includes convictions for auto theft, grand theft, and interstsate transportation of a stolen motor vehicle. He has escaped from custody on more than one occasion and is reported to be "hot-tempered." In August 1957, accompanied by his wife, Nelda Moore Shockey, he allegedly attacked his father-in-law at knifepoint, and a short time later, he reportedly attempted to kill his brother Robert with a .38 revolver at Creede, Colo. He has traveled the western states extensively and is believed to be accompanied by his wife Nelda at the present time.

Shockey is described as a white male, American, born June 21, in 1934 at Twin Falls, Idaho, 5' 11", 165 pounds, medium build, light brown hair, hazel eyes, medium complexion, seventh grade education, occupations—laborer, broom maker, sheet-metal worker, hydro-press operator, and paraffin cutter. The fugitive has a scar above his left eye and has on occasion, worn his hair long on the sides with a crew-cut top, and is inclined toward cowboy or western type clothes with low cut, motorcycle-type boots. Shockey is considered extremely dangerous and will reportedly shoot without provocation to avoid apprehension.

Any person having information which might assist in locating this fugitive is requested to immediately notify the Director of the Federal Bureau of Investigation, U. S. Department of Justice, Washington 25, D. C., or the Special Agent in Charge of the nearest FBI Division, the telephone number of which appears on the first page of local telephone directories.

What's New in EQUIPMENT and SERVICES

Drilling - Production - Exploration

Suspension Drilling Tool

A suspension drilling tool, designed for fast, safe and economical drilling, has been announced by Beck-Hill, Inc.

The tool is approximately 100 inches long with outside diameters varying from 3⅛ inches to 8½ inches O.D. The manufacturer is prepared to make tools up to 11 inches outside diameter as the demand arises.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.

Long Stroke Pumping Unit

A long stroke surface pumping unit has been announced by the Axelson Manufacturing Co., Division of U.S. Industries, Inc.

The stroke length of this new Axelson Hydrax unit is 31½ feet. Seven of the 31-foot units have recently been installed in the Permian Basin area for high volume and deep producing wells.

(This item supplements Axelson Manufacturing Co., Division of U.S. Industries, Inc., data on Pages 229-264, Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Drillmaster Made Tougher

Ingersoll-Rand's Drillmaster has been introduced with a "beefed-up" mounting that makes the versatile blast-hole unit more rugged and portable.

Set-up time for the unit, called the TRUCM-3 Drillmaster, is only a few minutes because the drill tower is raised and lowered by hydraulic power, putting the downhole drill into action almost immediately. This drill, which follows its steel right down the hole, has been known to drill 350 feet of hole during a single 8-hour shift.

(This item supplements Ingersoll-Rand Company data on Pages 2717-2724, Composite Catalog, 23rd [1958-59] Revision.)

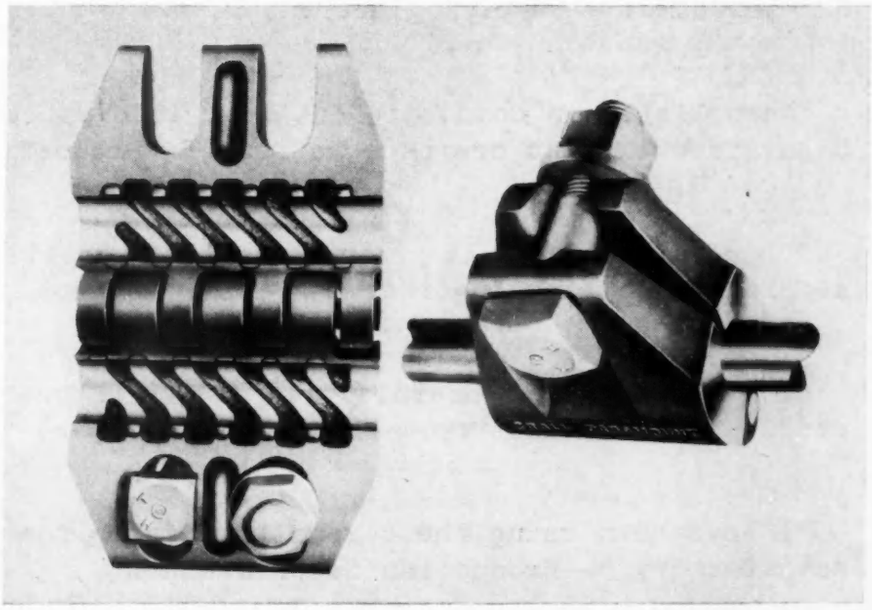
For more data, circle **No. E3** on Readers' Service Card, last page this issue.

Engine Driven Welders

New drooping-voltage arc welders are now available from Air Reduction Sales Company in three types—250-amp DC, 300-amp AC/DC and 300-amp AC/DC Heliwelder. All machines provide 115/230-volt, 10 kw, single phase, 60-cycle power when operated as power plants. They have 115-volt, 1 kw DC auxiliary power available for operating lights and power tools while welding.

The 250-amp DC machine is designed for general purpose construction and maintenance welding in the field, especially pipe line work. The 300-amp AC/DC machine is a remote area welder and power plant for AC welding and DC reverse or DC straight polarity welding current. The 300-amp AC/DC Heliwelder is for field operations where aluminum or magnesium structural welding is involved.

For more data, circle **No. E4** on Readers' Service Card, last page this issue.



New Unique 'Spiral-Grip' Polished Rod Clamps

Crall Products, Inc., of Pampa, Texas, announce the manufacture of the new Crall-Paramount, all steel "Spiral-Grip" Polished Rod Clamps which completely encircle the polished rod. Due to the unique construction of the offset spacing of the spiral in this new clamp, approximately 20 percent more gripping surface is assured than previously obtained from conventional clamps.

The body of this new Crall "Spiral-Grip" clamp is made from high tensile, heat treated AISI 1040 steel. The bolts, washers and nuts are case hardened and cadmium plated with heat treated and cadmium plated hinge pins, for utmost strength and resistance to corrosion. These

Here is What Oil Men Say . . .

Twenty-four hours a day, around the world, oil men are using COMPOSITE CATALOG. Shown below are a few comments* (typical of thousands received) from oil men in every oil producing country of the world:

"This catalog is used daily by our staff in ordering replacement parts and new equipment."—Drilling Foreman.

* * *

"Engineering and purchasing would have a hard time without it."—Production Engineer.

* * *

"Your Composite Catalogs are and have been very useful to me on both foreign assignments and present job."—Drilling Superintendent.

* * *

"It is of considerable value to me as a ready and constant reference to equipment available."—Division Production Superintendent.

* * *

"I can never thank you enough for the many hours your Composite Catalog has saved me."—Chief Engineer.

* * *

"When listed in Composite Catalog, information is at your fingertips. Separate bulletins are hard to find."—Production Engineer.

* * *

"Composite Catalog is a very important asset. It would take hours to keep separate bulletins in order."—Vice President.

* * *

"You have the most useful piece of literature in the drilling-producing section of the industry."—Division Engineer.

* * *

"I have been using the Composite Catalog for 25 years and find it very satisfactory."—Production Superintendent.

* * *

"We use our Composite Catalog to check all new improvements—to compare equipment before a purchase."—Drilling Contractor.

* * *

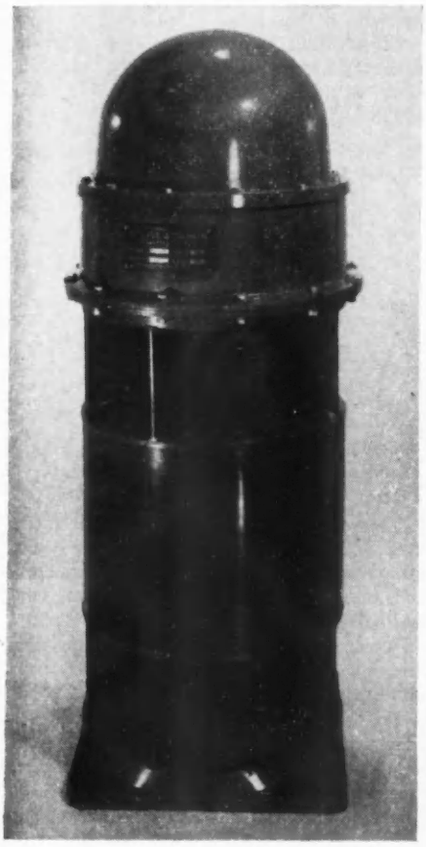
* Originals in all cases are on file in Gulf Publishing Company's Houston office.

new polished rod clamps are both machine bored and reamed to exact polished rod size with both ends machine faced exactly 90 degrees to the bore which assures a straight pull or load on the polished rod at all times with no bending or marring of the polished rod.

Crall-Paramount "Spiral-Grip" Polished Rod Clamps are full opening for quick, easy one-man installation. The clamps are field tested and proven and meet API specifications for pull tests. The clamps are manufactured in one bolt and two bolt sizes. The one bolt, Series 180, maximum recommended polished rod load is 25,000 pounds, and the two bolt, Series 280, maximum load is 40,000 pounds.

(This item supplements the Crall Products, Inc., data on Pages 1470-1471 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E5** on Readers' Service Card, last page this issue.



Fiberglass Fog Horn

Wallace & Tiernan Incorporated has introduced a new fog horn designed to meet present U.S. Coast Guard requirements for a ½-mile fog signal. The new horn is a battery operated air oscillator, fabricated from fiberglass for complete corrosion resistance and light weight.

The new fog horn is designed to direct the greatest amount of sound energy into the horizontal plane with uniform intensity. The sound pattern is a perfect circle in the horizontal plane and has no measurable lobes.

For more data, circle **No. E6** on Readers' Service Card, last page this issue.

Alloy Steel Gate Valves

Triangle Valve Company, Ltd., announces through-conduit wellhead gate valves for wellhead and similar services.

The body is an alloy, steel casting featuring pressed-in bronze seats with extended working faces and a unique pressure-sealed gasket for the bonnet joint. The bonnet and bonnet ring are manufactured from alloy steel forgings or castings according to size, with the bonnet being retained in position by the engaging of the screwed bonnet ring with the threaded body neck.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

Quality
BUILT
. . . to give you long economical life

The long life of Wichtex units is a legend in the well servicing industry. Long life with minimum repairs . . . mobility . . . and fast, easy operation make Wichtex units a top investment. It will pay you to investigate:

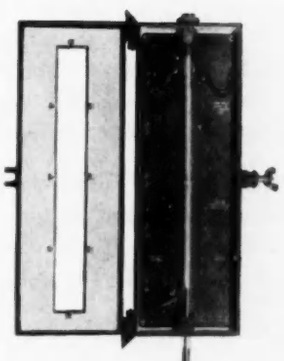
WICHTEX WELL SERVICING UNITS
2,000′ to 12,000′ capacity
—spudding attachment optional

WICHTEX PORTABLE ROTARY RIGS
2,000′ to 5,000′ capacity

WICHTEX
MACHINERY COMPANY
P. O. Box 2250
Wichita Falls, Texas

A NEW AND BETTER
LIQUID LEVEL CONTROLLER

For controlling high and low levels in a variety of tank operations. *Especially ideal for surge tanks on lease automatic custody transfer units.* Easy to install . . . fully automatic . . . maintenance free!



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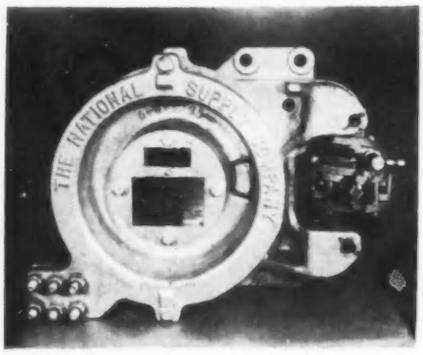


New Weight Indicator

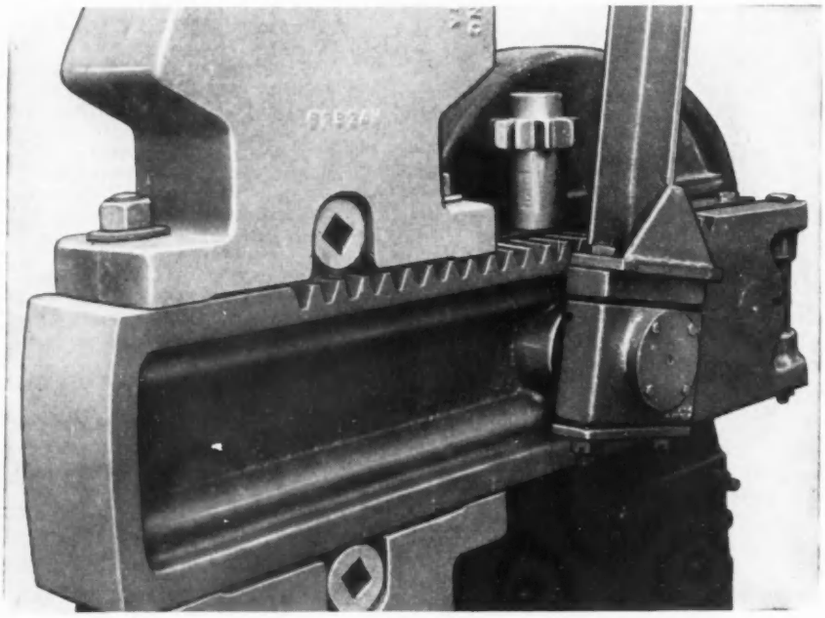
The Martin-Decker Type "F" weight indicator is now available for the first time with the company's Sensater sensing element as an integral part of the wire line anchor.

The new model, known as the Type "FS", now combines all the accuracy and sensitivity advantages of the larger Martin-Decker Type "E" and "D" weight indicators which have been used for many years by drillers in every drilling area of the world.

The Sensater realizes every weight change immediately, no matter how small. The strong competition in the medium drilling range makes the Type "FS" the best insurance for an operator to get the best use of all drilling time. The rugged, nylon reinforced Sensater diaphragm is substantially unaffected by temperature changes. It derives its outstanding accuracy and sensitivity from a specially designed and patented diaphragm which makes a stroke similar to a piston's travel, but with a minimum of friction.

(This item supplements the Martin-Decker Corporation data on Pages 3173-3200 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E8** on Readers' Service Card, last page this issue.



MAXIMUM EFFICIENCY . . .

. . . when you equip your well with JENSEN's new Rotary Balanced Jack. JENSEN's unique rack-and-pinion system is a breeze to adjust, gives both lead and lag counterbalance . . . for smoother stroking power and longer pump life.

The JENSEN Rotary Jack also features heavier main shafts and bearings—a taller, more rigid Samson Post. It's a rugged unit—built to last for the life of your well.

Oilmen everywhere are talking about this new JENSEN JACK. Get all the facts for yourself.

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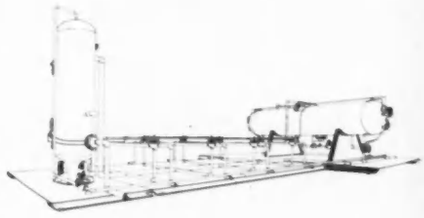
Export Office: 250 Park Avenue, New York 17, N. Y.

JENSEN JACKS



Test and Production Unit

This new Odex Engineering unit measures total fluid production of lease—plus oil, gas and water for each well in sequence. It is designed for automatic operation, controlled at the lease or at a remote central office to program and monitor production and receive instant warnings of off-normal conditions.

For simple field installation and economy, the unit is pre-engineered to lease requirements and prefabricated in three side-mounted sections; metering separator, manifold and metering free-water knockout. Additional manifold units are easily tied in as the number of wells increases.

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

Drill Collar Compound

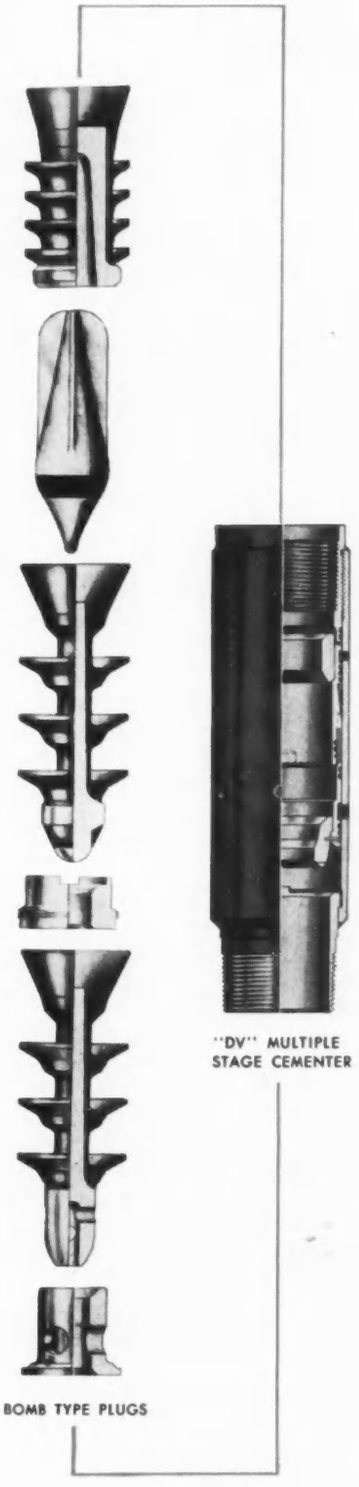
Molykote deep well drill collar compound, a molybdenum disulfide product, is now being manufactured and marketed to the oil well drilling industry by The Alpha-Molykote Corporation.

The new product will prevent galling and seizing and provide easy break-out of large diameter drill collars at extreme depths and high temperatures.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

MULTIPLE STAGE CEMENTING...

provides a wider selection of well completion techniques



"DV" MULTIPLE STAGE CEMENTER

BOMB TYPE PLUGS

Here are just a few advantages, when you complete your wells with Halliburton's versatile DV Multiple Stage Cementers:

- **Full Depth Cementing**
- **Cementing Off Formation at Any Pre-Determined Point**
- **Dual Zone Well Completion**
- **Reduced Pump Pressures**
- **Protection Against Loss of Cementing Slurry to Thieving Formations**

Only one DV Cementer and set of plugs is required for two stage cementing... two DV Cementers and special plug set for three stage cementing. Tools with bomb type or displacement type plugs are available in tubing or casing sizes ranging from 2½" EUE to 13⅜" O. D.

Thousands of successful intermediate and production string cementing jobs have been completed with Halliburton's precision built differential valve "DV" Multiple Stage Cementers. Halliburton's unique tools incorporate a novel principle of hydraulics which allows precision placement and control... making it possible to effectively place more than one stage of cement on the outside of the same string of casing at selected points... in most any well regardless of depth, pressure or temperature.

See your nearby Halliburton Representative for the multiple benefits of Halliburton Multiple Stage Cementing.

HALLIBURTON
CEMENTING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY • DUNCAN, OKLAHOMA

284 SERVICE CENTERS—JUST MINUTES AWAY FROM YOUR WELL

Lightweight Field Trailer

A new type of lightweight field trailer, transportable by helicopter or airplane, has been developed by Elder Trailer and Body, Inc., Denver.

Elder's new "air-lift" trailer was designed specifically for field crews operating in remote locations, particularly in arctic or jungle regions, accessible only by air. The "air-lift" trailer separates into two sections for shipment by helicopter, or "knocks down" for shipping in aircraft. Fully insulated for all-weather comfort, "air-lift" trailers are available in completely equipped units—kitchens, diners, sleepers, showers, lavatories and offices. Trailer shells can be ordered for use as workshops, radio stations or general storage trailers.

"Air-lift" trailers are equipped with skid-mounts or detachable running gear: standard single action running gear, walking beam running gear with tracks or running gear with low pressure Terra tires for soft sand and snow.

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

FOR USE IN DRILLING OPERATIONS

Kirkose

SPANS THE WORLD

'KIRKOSE' SODIUM CARBOXYMETHYL CELLULOSE • USED ON A WORLD-WIDE BASIS FOR FLUID LOSS PREVENTION • AVAILABLE IN LOW AND HIGH VISCOSITY GRADES • SALT RESISTANT SUITABLE FOR BRINE MUDS AS WELL AS FRESHWATER MUDS

"In certain Countries of the world the use of S.C.M.C. for drilling operations is covered by patent rights, in connection with which we are empowered to grant licences. In sales for use in these countries (U.S.A., Canada, Mexico, Iran, Colombia, Iraq, Brazil, France) we pay a royalty to Drilling Specialities Company, Bartlesville, Oklahoma, of 7c. per lb. actual S.C.M.C., which is included in our selling price. In consequence, drillers in these countries are licensed to use our product for any drilling operations."

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Issued by the Chemical Division of KIRKLEES LTD., BURY, ENGLAND

Portable Pump

A compact, trailer-mounted hydraulic system has been devised by Harris Sisson Rental Tongs, Inc., to speed work in repairing oil well pumps. Engine and hydraulic pump are mounted on a four-wheel trailer which can be towed quickly and easily behind a car or pick-up truck from job to job.

The hydraulic system powers the Foster tongs used to pull the tubing and pump out of the well. The hydraulic pump is a Byron Jackson and is powered by an International U-123 carbureted engine.

For more data, circle **No. E12** on Readers' Service Card, last page this issue.

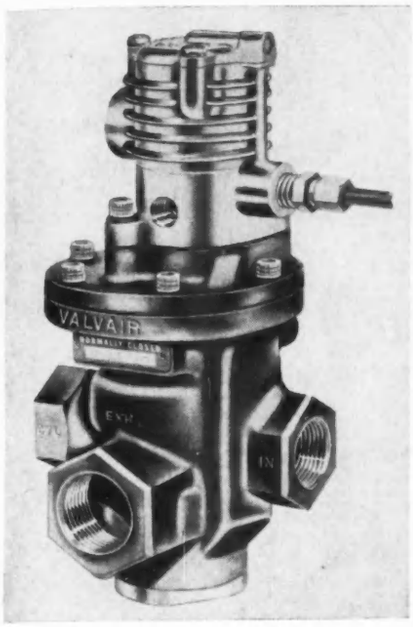
Low Noise Amplifier

Small fractions of a microvolt may now be detected and amplified by the recently developed Galvanometer-Phototube Amplifier, Model 4300, available from The Geotechnical Corporation.

A voltage gain of ¼ million and a noise level of less than .025 microvolt rms referred to input are typical of performance when for example, a Geotech 5-cps

mirror galvanometer is employed. Other features are a drift of less than 0.1 microvolt referred to input over an eight-hour period; a dynamic range of at least 70 db, noise level to clipping level; and a linearity of ± 2 percent, noise level to 75 percent clipping level, based on best straight line. The frequency limits and performance of the instrument depend upon the galvanometer and filter chosen.

For more data, circle **No. E13** on Readers' Service Card, last page this issue.



Hi-Speed Control Valve

A new hi-speed inline poppet-type, pilot operated control valve, designed for external pilot supply, is announced by Valvair Corporation.

Intended for brake, clutch and other high speed operations where main operating pressure is below 20 psi, where the valve is controlling vacuum down to within 1 inch Hg absolute, or where pressure on the valve is reduced below 20 psi for machine setup, Valvair's new inline is reputed to afford split-second response due to extremely short poppet travel. This fast response shortens machine cycle time with a matching increase in work output, provides more accuracy for high speed cut-off, reduces maintenance expense and increases operating safety by minimizing over-travel and drift.

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

Axite Upper-Barrel Tube Connector

The Axite material, which has been successfully used for hard-facing sub-surface pump plungers, is now available on the Axelson traveling type upper-barrel tube connector. It's another new product from the Axelson Manufacturing Company, Division of U. S. Industries, which has recently been put on a production basis to assist operators in producing problem-type wells.

The micro constituents of the Axite material is in the hardness range of a sapphire rating of nine on the Mohs scale; diamonds have a rating of 10. The material's resistance to wear, abrasion and greatly reduced coefficient of friction may all be attributed to this hardness.

The density and high-nickel content of this material often protects the part from failure due to corrosion fatigue. This is born out through evidence accumulated on parts which indicate accelerated corrosion on a surface subject to wear. The Axite sprayed band on the adapter reduces wear; hence, will provide a limited corrosion control. The connector is available for RWT and RLT type pumps.

(This item supplements the Axelson Manufacturing Company's data on Pages 229-264 of the Composite Catalog, 23rd [1958-59] Revision.)

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

Vise Stands

The addition of two new combination vise and vise stands to their line of pipe tools has recently been made by The Toledo Pipe Threading Machine Company.

According to the manufacturer, bruised knuckles are a thing of the past with the new 7C, since the large tightening handle is on top. Compound leverage is applied to chain that falls into lever hook automatically, requiring minimum turns on screw.

For more data, circle **No. E16** on Readers' Service Card, last page this issue.

BRITISH H-E MADE

300 P.A. TRACTOR DRILLMASTER

MULTI-PURPOSE · HIGHLY MOBILE

The Hands-England Drillmaster 300 P.A. Rotary Drill is now available mounted on a Fordson Major Tractor and is illustrated on left.

This design provides great manoeuvrability and is intended primarily to enable the well known H-E Drillmaster 300 P.A. Rotary Drill to be used for Quarry and Open Cast blast or shot holes.

Although the H-E Drillmaster 300 P.A. mounted on a diesel engined tractor, is ideal for Quarry and Open Cast operations, it is equally applicable to some difficult "off the road" locations, such as may be encountered during seismic exploration particularly in highly cultivated areas.

An air compressor giving 99 C F M can be mounted directly onto the drill subframe and driven from the tractor engine. This compressor gives an up-hole annular velocity of 3,000 ft./min. when using flush jointed drill pipe and holes of the following sizes:

1⅝" o/d. Drill Pipe	2⅞" dia. hole
1.29/32" " "	3⅛" " "
2⅜" " "	3⅜" " "
2⅞" " "	3¾" " "

Larger holes or holes drilled with mud circulation can of course be drilled, but the equipment for these operations must be mounted on a separate trailer or tractor.

The H-E Tractor Drillmaster will be found to cover the majority of drilling requirements of the Quarry and Open Cast operator, the Geologist, the Mineralogist, and the Geophysicist.

Write for illustrated folder, full detail and specifications of this equipment quoting Reference D/TD.

HANDS - ENGLAND OILFIELD EQUIPMENT LTD

MANUFACTURERS OF GEOPHYSICAL SUPPLIES

LETCHWORTH HERTS ENGLAND TEL: 600 CABLES: OIL LETCHWORTH ENGLAND

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because of this spring

Johnston is tops in testing

Actually, this chrome vanadium steel spring is only one of many reasons why Johnston Is Tops In Testing. A noteworthy achievement in metallurgy, its ultra low thermal coefficient and its ability to deflect up to five inches under pressure makes it the ideal tension member for pressure recording instruments. Thus, in sensitivity, accuracy, and behavior under high bottom hole temperatures, it is far superior to any other formation pressure measuring device. For example, on standard field 0-7000 psi range instruments, pressure changes of only 2½ pounds are observed continuously . . . a sensitivity of 5/100 of 1 per cent!

A rugged built-in thermometer and chronometer leave nothing for the imagination. Only a final completion can provide a more accurate productivity index.

So, why be satisfied with an approximate reservoir evaluation when Johnston Testers enable your engineers to see the true picture?

JOHNSTON

first in drill stem testing

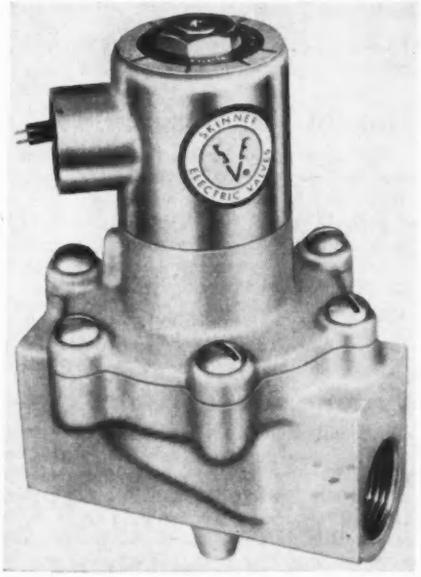
Aerial Plotter

The Bausch & Lomb Optical Co. announces the addition of Balplex 760 plotter to its line of photogrammetric mapping equipment. The new aerial plotter complements the present Balplex 525 and Multiplex 360 plotters.

The Balplex 760 provides 5X enlargement of the original aerial negative, making the new instrument especially well-suited for highway and waterway mapping projects where large scale accuracy and detail are of primary importance.

In addition to increased magnification, the Balplex 760 provides such features of the standard Balplex as permanent calibration and ground control extension capability.

For more data, circle **No. E17** on Readers' Service Card, last page this issue.



High-Flow Valves

A new series of high-flow, two-way valves with ¾-inch and 1-inch diameter orifices are announced by Skinner Electric Valve Division.

These L series valves are designed to control such common media as air, oil and water and are smaller and more compact than the M2 series valves they replace. The valves operate on a pressure differential of 5 to 150 psi and are available in standard and explosion proof construction, normally open or normally closed. They mount directly to a line in any position and can be serviced without removal.

For more data, circle **No. E18** on Readers' Service Card, last page this issue.

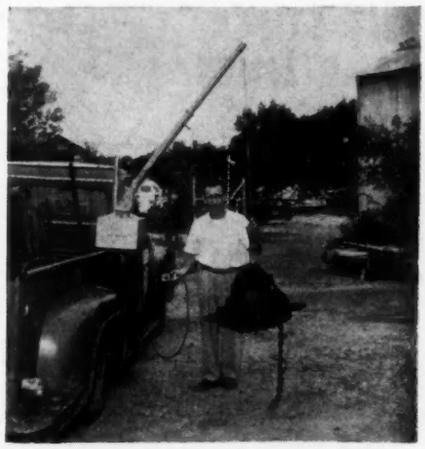
Powered Lifting Hoist

A new powered lifting hoist, called an auto crane, has been developed to make feasible one handling of loads up to 1,000 pounds, thus eliminating need of helpers.

The hoist can be easily installed in the trunk of a car or in the bed or on the side of a pick-up. It takes up little or no space and runs off the battery (6, 12 or 24 volts). It is operated, by a cable mounted movable hand switch.

It is made and sold by Auto Crane Co.

For more data, circle **No. E19** on Readers' Service Card, last page this issue.



Write for this NOW!

"How to use three-phase motors on SINGLE-PHASE CURRENT"

. . . and profit from the added economy and efficiency!

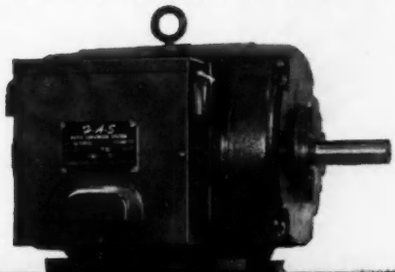
Three-phase motors cost less than single-phase motors, are more efficient, and have far greater salvage value.

The NEW H-A-S Phase Conversion System enables you to use three-phase motors (3 h. p. or larger) on 220 V single-phase current. Three-phase motors cost less, operate for less, and can be used later on three-phase current.

On many rural single-phase lines service is limited to 5 h. p. single-phase motors, but the H-A-S Phase Conversion System permits the use of three-phase motors up to 75 h. p.

The H-A-S is available in two models, for motor mounting and remote mounting.

This is GOOD NEWS in the oil country. To solve an immediate problem —or for your files—write NOW for complete details and the name of your nearest supply store or distributor!



KEN ELLIOTT MOTORS, INC.
P. O. Box 5158-B
BOSSIER CITY, LOUISIANA

H-A-S PHASE CONVERSION SYSTEM

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KINLEY SAND LINE CUTTER

M. M. Kinley Company, Licensees

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BAY CITY, TEXAS—J. P. Graham.....CI 5-4526
BEAUMONT, TEXAS
Assoc. Eng. & Eqpt., Inc....TE 5-7046, ZF 8-2023
CASPER, WYOMING—C. A. White.....3-5264
GLENDIVE, MONTANA—C. A. White...EM 5-3833
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Horne Well Service Co.....3-5396
HOUMA, LOUISIANA
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KILGORE, TEXAS
Davis-Kemp Tool Co., Inc.....5541
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Assoc. Eng. & Eqt., Inc.....CE 5-6770
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Rainbo Service .....Main 4-3598
LINDSAY, OKLAHOMA
Rainbo Service Co.....PL 6-2530
MIDLAND, TEXAS
Luccous Service & Eqpt. Co.....MU 2-1631
OKLAHOMA CITY, OKLAHOMA
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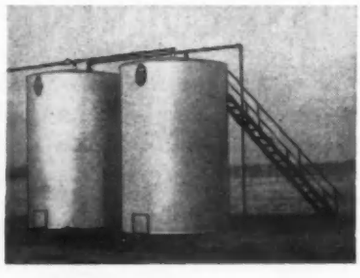

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Steel Fabrication for the Oil Industry

New Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Readers' Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

New Swab Bulletin

Byron Jackson Tools, Inc., a subsidiary of Borg-Warner Corporation, offers a new 4-page, 3-color bulletin covering its new hydro-dynamic tubing swab. The swab has a simple, two-piece steel body designed to accommodate a pair of either of two types of swab rubbers—cup type or multi-disc type.

Any tubing swab operation can be performed with the one body and two types of rubbers. The efficient swab falls faster because of annular clearance going down, and adjusts itself to any size load on the way up. Included in the bulletin are color photographs and diagrams illustrating the use of the new swab, along with complete specifications for tubing swabs and components.

To get a copy, circle **No. E20** on Readers' Service Card, last page this issue.

V Belt Drives Manual

A new 12-page illustrated manual, "How to Get Longer Life from V Belt Drives," has been issued by B. F. Goodrich Industrial Products Company, Akron, Ohio.

The manual tells how to select and install V belts, how to detect V belt trouble, diagnose belt failures, correct drive troubles. A list of valuable tips for proper V belt maintenance is included as well as a suggested inventory survey check list for V belt drives.

To get a copy, circle **No. E21** on Readers' Service Card, last page this issue.

Pumping Units Bulletin

Two beam counterbalanced pumping units with API unit structure ratings of 4710 and 7240 pounds are presented by The National Supply Company, Pittsburgh, in a new 8-page Bulletin No. 474. The Bulletin describes the National Type E-5 and E-7 pumping units with respective peak torques of 16,000 and 25,000 inch-pounds. Detailed construction and operating features are illustrated.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

Pumping Unit Pointer No. 8

A successful pumping unit operation depends largely on a well-planned maintenance program is the thought that is conveyed in the "Pumping Unit Pointer No. 8" which is now being offered by The National Supply Company.

Previous Pumping Unit Pointers covered various phases of installation and maintenance which are sometimes overlooked or practiced incorrectly. Pointer No. 8 is a summary of the most important items covered in the previous Pointers.

To get a copy, circle **No. E23** on Readers' Service Card, last page this issue.

Recording Tape Brochure

ORR Radio Industries, Inc., has announced an attractive 8-page, four-color brochure on Irish Ferro-Sheen geophysical tape is now available to all industries, firms and organizations interested in seismic recording.

The brochure is the same size as a standard file folder (11x8½ inches) and is made up like a file folder so it may be filed more conveniently. A protruding tab easily identifies the brochure when it is filed with other literature.

The pamphlet is divided into three sections: (1) general information, (2) product and features, (3) manufacture and quality control.

To get a copy, circle **No. E24** on Readers' Service Card, last page this issue.

Oil Plunger Bulletin

The Fluid Packed Pump Company has announced that the Oilmaster Oil Lubricated Plunger is described in a new four-page Technical Bulletin EC 5805. The new bulletin covers operational details, general description, specifications and cataloged parts information.

To get a copy, circle **No. E25** on Readers' Service Card, last page this issue.

Control Valve Bulletin

Conoflow Corporation has just issued a new bulletin describing the company's complete line of Series LB control valves.

Bulletin LB-3 is a well illustrated 12-page booklet which gives details on construction and operating characteristics of the Series LB control valve.

To get a copy, circle **No. E26** on Readers' Service Card, last page this issue.

Cyclone Bibliography

An enlarged and revised bibliography on the liquid-solid cyclone has been completed by minerals beneficiation specialists at Battelle Memorial Institute, Columbus, Ohio. Prepared by Oscar F. Tangel, Robert J. Brison, and Daniel A. Jacobs. The new bibliography lists 243 articles on the liquid-solid cyclone that were published from 1939 through 1957, with some early 1958 entries included.

The bibliography lists articles on the theory and design of this equipment and on its use in the mineral processing, pulp and paper, petroleum, chemical, and food-processing industries. A general category of entries includes references to review articles, books, bibliographies, and articles general in nature.

To get a copy, circle **No. E27** on Readers' Service Card, last page this issue.